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City of Vancouver

Dennis Fan
Greenest City Scholar

[GREENING A HERITAGE BUILDING]

Literature review and case study synthesis on the benefits of heritage building conservation and how sustainability focused strategies may be applied to enhance both environmental performance and heritage conservation.

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Executive Summary

Through existing 1&2 Family (1&2F) house retrofits alone, it is possible to achieve 65% of Vancouver's targets for greenhouse gas reduction in existing buildings. Based on ecoENERGY[1] retrofit data of recently retrofitted Vancouver houses, an average reduction of 1.35 tonnes of CO_2/year/house was estimated. When applied across Vancouver's 170,000 1&2F houses, there is potential to reduce 150,000 tonnes of CO_2/year.

When the retrofit data is discretized by decade, heritage and character houses (typically built pre 1940s) had the highest greenhouse gas reduction. Through appropriate rehabilitation of 26,000 pre-1940s houses in Vancouver, there is an opportunity to reduce 52,000 tonnes of CO_2/year.

The environmental performance of existing buildings, including heritage and character houses, can be equal to or outperform new construction when we consider the full cycle accounting of carbon and other waste materials. Using life cycle assessment (LCA) and energy modeling, a rehabilitated Victorian Arts & Crafts style house in Victoria BC was shown to have less environmental impact over its lifetime and achieved better performance than new construction in energy efficiency, achieving EnerGuide 80. Furthermore, LCA data by Quantis for Vancouver typology homes show that the avoided environmental impacts over the life cycle for renovation of a heritage house is equivalent to saving 35 years of operational energy of a new efficient house.

[1] The former ecoENERGY Retrofit – Homes program, from April 2007 to March 2012, provided incentives for home owners to make their home more energy-efficient. Participants needed to obtain a pre-retrofit evaluation by a certified energy advisor using the EnerGuide Rating System before starting work and a post-retrofit evaluation within program deadlines.

1.0 Introduction

Vancouver's 2020 Greenest City Action Plan seeks to transform Vancouver into the greenest city in the world by 2020. The City's goal for climate leadership is to reduce community-based greenhouse gas (GHG) emissions by 33% over 2007 levels. The reduction is planned to be achieved through renewable energy, buildings, transportation, and waste reduction. The city's green building target includes addressing the existing building stock to "reduce energy use and greenhouse gas emissions in existing buildings by 20% over 2007 levels." (City of Vancouver, 2012)

Of the city's total GHG emissions, 1&2F Homes account for the largest portion at 19%; this figure includes heritage and character houses which are mainly constructed prior to 1940. There has also been an increase in the loss of heritage [2]and character houses to new development. This report therefore looks to address the rehabilitation of heritage and character homes to both increase environmental performance and retain heritage value.

Heritage and character houses found in Vancouver are mainly constructed prior to the 1940s and provide a record of history and architectural value to our communities while telling the story of Vancouver's growth and expansion. Figure 1 is a visualization of the different ages of Vancouver building stock by their year of construction. This figure shows the growth and development of different neighbourhoods through the past century. For example, the yellow and orange areas show the initial development of houses in Vancouver in the Kitsilano, Shaughnessy, and Grandview Woodland neighbourhoods.

Just as the coloured map tells us the years of each neighbourhood's development, the houses represent architecture typical to each era and tell a much richer tale.

[2] Heritage houses are listed on the Vancouver Heritage Register (VHR), character houses may also have heritage value but are not formally listed on VHR

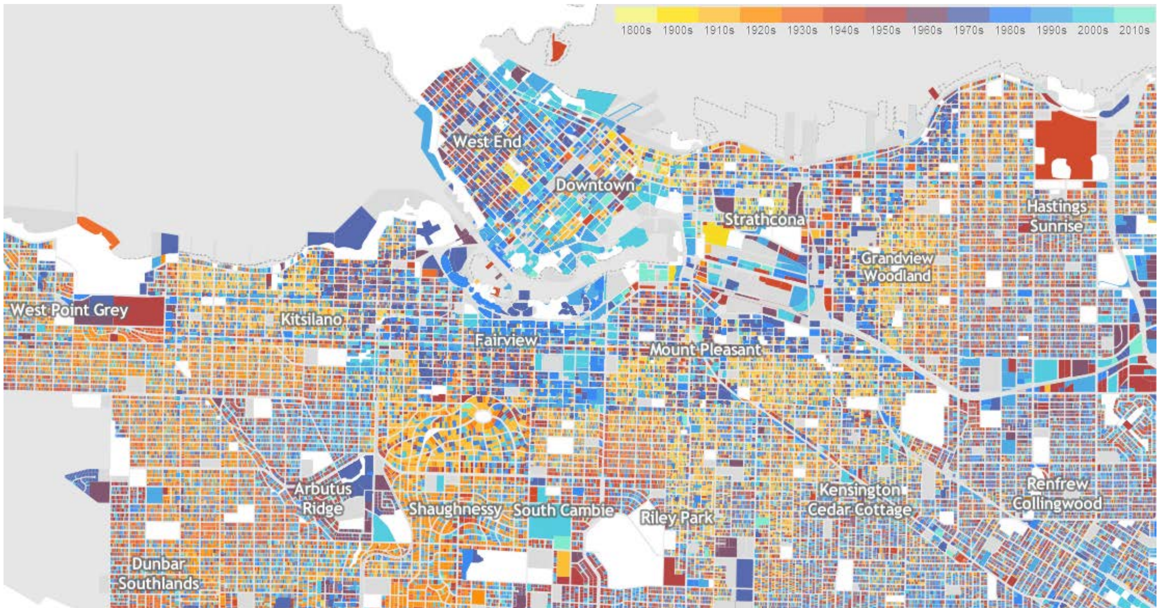

Figure 1: Age map of Vancouver buildings by Ekaterina Aristova[3]

The definition of conservation must first be established to discuss heritage conservation. The conservation of historic places, as defined by Parks Canada, is:

> "all actions or processes aimed at safeguarding the *character-defining elements*[4] of an historic place to retain its heritage value and extend its physical life."

Parks Canada also recognizes that there exists a balance between protecting heritage value and adapting existing resources to meet the new needs of users, and that an optimal solution balances both to sustain the continued use of existing building stock. (Parks Canada, 2010) Furthermore, while 96% of Vancouver residents support heritage conservation, only 72% strongly agree that heritage buildings contribute to an environmentally sustainable city. (Vancouver Heritage Foundation, 2012)

This report looks to address the question of how best to approach existing building stock, in particular heritage and character houses, to both improve environmental performance and retain heritage value.

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[3] Source: http://www.aristova.me/projects/vancouver-building-age-map/
[4] Character-defining Element: the materials, forms, location, spatial configurations, uses and cultural associations or meanings that contribute to the heritage value of a historic place, which must be retained to preserve its heritage value.

2.0 The Role of Heritage and Vancouver's 2020 Plans

Heritage friendly retrofits are targeted towards houses with historic or heritage value. While the focus of this report will be on measures that preserve character-defining elements found in both heritage and character houses, the measures are equally applicable to any existing house. To preserve the character-defining elements of a building, the identified measures are typically both non-intrusive and environmentally friendly, and should be done for all existing building stock regardless of heritage value.

Green retrofit measures reduce energy consumed by buildings, thus reducing electricity generation or combustion of natural gas for day-to-day activities, such as heating, which generates GHG emissions. The the aim of green retrofits of existing houses is to reduce the city's GHG emissions.

Data from energy improvement retrofits of Vancouver houses from 2008-2013 was analyzed and the results, illustrated in Figure 2, indicate a correlation between GHG savings and age of building stock. The largest savings were found for houses constructed prior to 1910. For heritage and character houses, constructed prior to 1940, the average GHG savings was 1.97 tonnes CO_2/year/house.

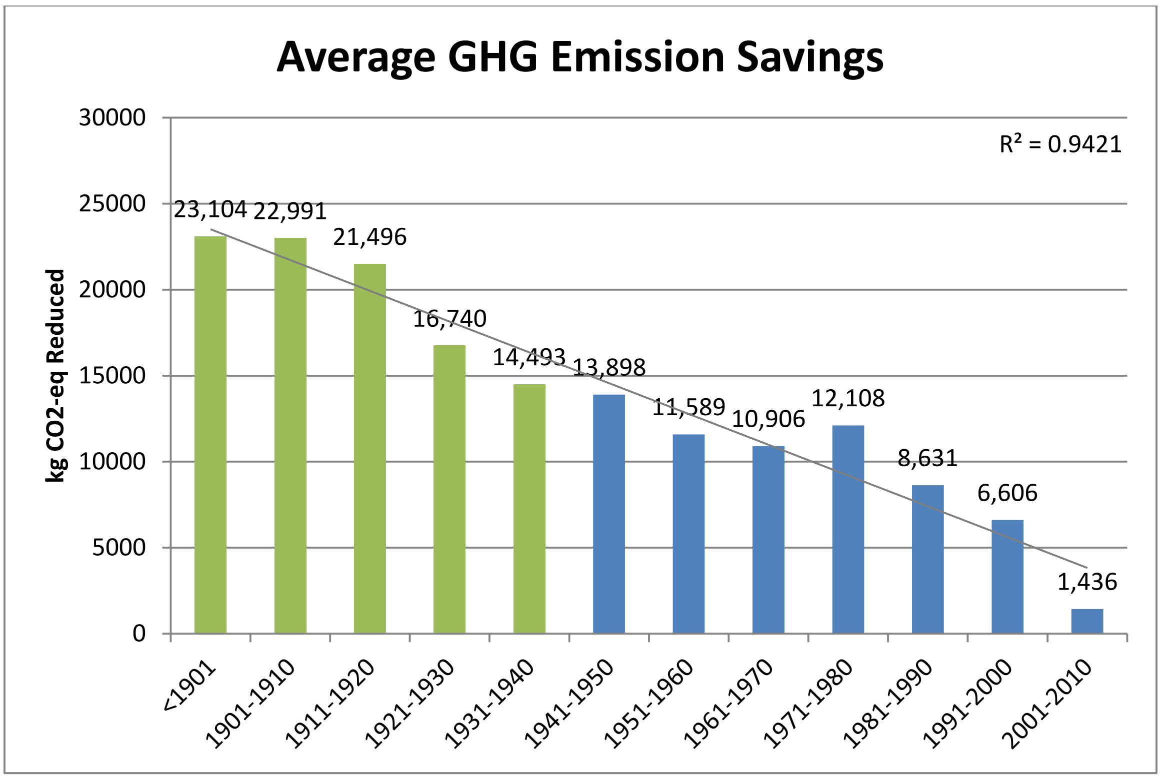

Figure 2: Average greenhouse gas emission reduction from home retrofits sorted by age

Property tax information from Vancouver's Open Data Catalogue, illustrated in Figure 3, indicate that there are approximately 26,000[5] houses in Vancouver that were constructed prior to 1940. At an average savings of 1.97 tonnes of CO_2/year/house there is potential for retrofits of pre-1940 houses to reduce over 52,000 tonnes of GHG to meet 22% of Vancouver's target GHG reduction target for existing buildings.

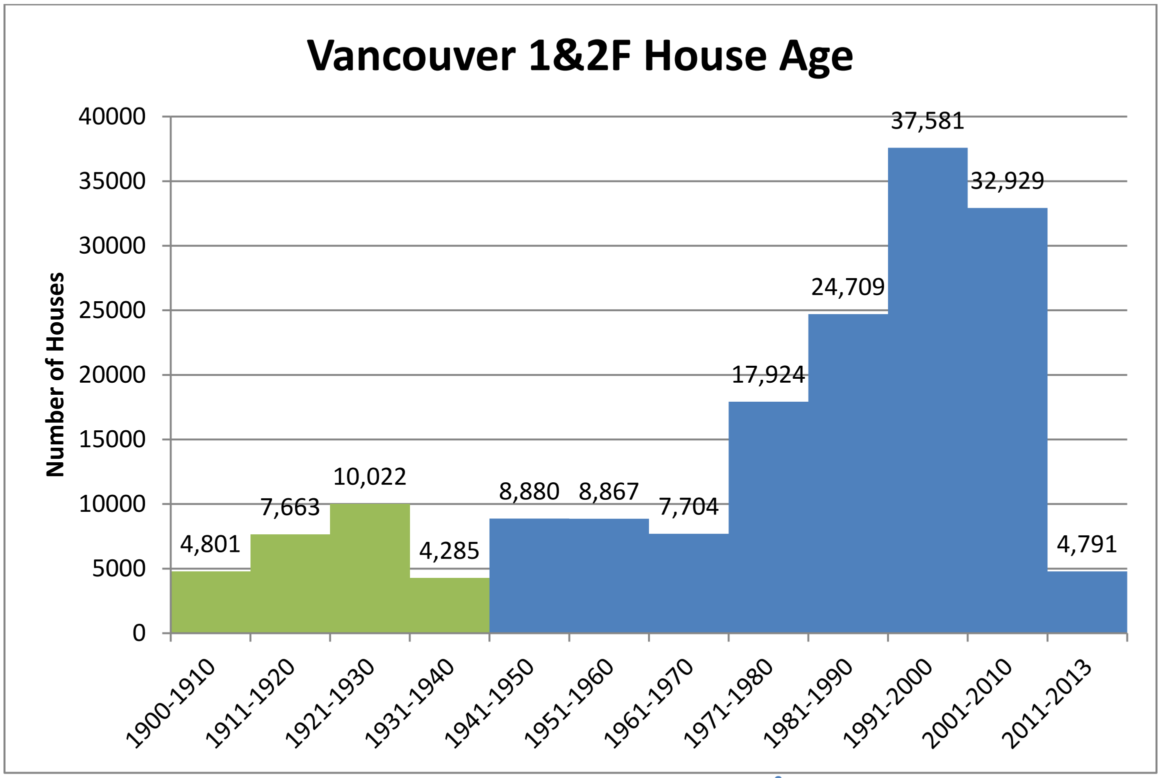

Figure 3: Histogram of Year Constructed for Vancouver 1&2F Homes[6]

If the same approach is taken to analyze houses of all ages, the average GHG reduction for houses is 1.35 tonnes CO_2/year/house. When applied across the 170,000 1&2F houses in Vancouver, there is potential for a reduction of 150,000 tonnes of CO_2. This 150,000 tonne CO_2 reduction would achieve 65% of Vancouver's existing building GHG emission reduction targets.

The savings analyzed were achieved through various retrofit incentives, such as LiveSmart BC and ecoENERGY, which provided rebates for upgrading of space heating, domestic hot water, basement insulation, ceiling insulation, and wall insulation.

[5] Summation of first four bars in Figure 3
[6] From City of Vancouver Open Data Library – Property Tax Report

2.1. Opportunities for Improvement

After analyzing the success of the retrofit program from a sustainability and heritage retention perspective, there are opportunities to improve program alignment with heritage conservation. A challenge identified by sustainable heritage consultant CityGreen is the disconnect between the needs of traditional style buildings and retrofit incentives. Current rebates include inappropriate incentives for heritage conservation such as replacement of traditional windows with vinyl Energy Star windows. (Cushing, 2010)

In addition, incentives do not align with whole building approaches to maximize value and heritage retention, which is explained further in section 5.0. CityGreen and GLOBE Advisors in the 2013 Home Energy Performance Industry analyzed and identified that there is a need to address retrofits on a house-as-a-system approach, which would benefit both cost benefit for retrofit incentives and allow enough flexibility to preserve historic characteristics of houses. (GLOBE Advisors, 2013)

It is recommended that heritage stakeholders in Vancouver become more engaged and actively participate in the discussion and planning for future retrofit incentives. Heritage stakeholders may pursue opportunities identified in the Home Energy Performance plan such as certification of the weatherization industry, which is highly fragmented and inconsistent and a possible driver of consumer confidence in contractors. Figure 4: Framework for market transformation illustrates the relationships between decision makers, governments, and industry associations for house retrofits. (GLOBE Advisors, 2013)

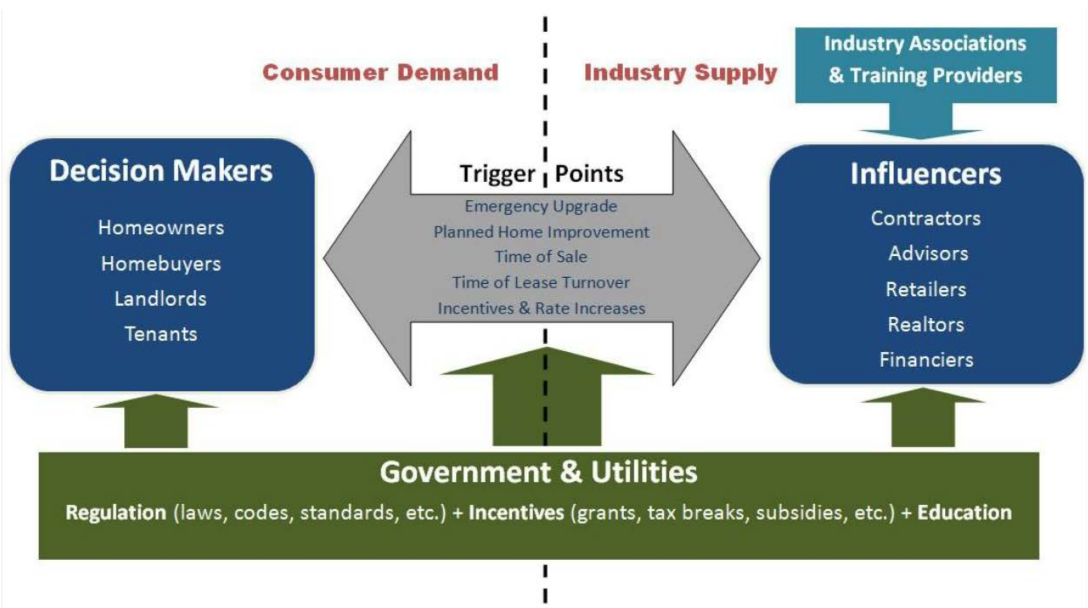

Figure 4: Framework for market transformation (GLOBE Advisors, 2013)

3.0 Environmental Benefits

Environmental benefits of heritage conservation extend beyond GHG emission savings during operations. Impacts avoided through building reuse, in particular non-carbon impacts such as ozone depletion, waste generation, resource consumption and human health effects, are often overlooked.

3.1. Embodied Energy vs. Avoided Impacts

There is a constant challenge to bridge the gap between operational energy and embodied energy when making comparisons between heritage and new buildings. Historically, embodied energy has been the main comparison tool to measure the value of materials that are present in an existing structure. However, the embodied energy approach measures the retrospective value of the building which is the value in terms of energy that was expended. Newer tools such as Life Cycle Assessment (LCA) allow more accurate accounting of not just energy stored within the material, but all impacts upstream and downstream, from cradle-to-grave, in the use of the materials.

This new approach looks at the avoided impacts, which takes into account the impacts of new construction and what can be avoided by reusing the existing structure. This approach compares historic buildings to new construction by analyzing impacts associated with the changes needed to improve the existing building versus a total replacement with a comparable new building.

> The "avoided impacts" approach measures environmental impacts avoided by choosing not to construct new buildings. (National Trust for Historic Preservation, 2011)

A key difference between the embodied energy and the avoided impacts (LCA) approach is the unit currencies used to communicate the models. The embodied energy approach uses units measured in GJ, commonly translated to litres of gasoline, whereas the avoided impacts approach uses units such as metric tonnes of CO_2. (Hasenfus, 2013) The avoided impacts approach, measured in tonnes of CO_2, aligns with modern sustainability goals and practices and produces more effective communication. Mike Jackson, a noted individual in the preservation field, notes that the avoided impacts approach is similar toa reframing of analyzing existing building value in the modern era.

3.2. Life Cycle Assessment

Life Cycle Assessment ISO 14044 is an international standard and tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. LCA is useful for the comparison of two products or systems with similar functions that can be simplified into “functional units” to normalize the services provided by any good. For the cases presented, the functional unit has been addressed through careful selection of appropriate building programming and size.

The output of a LCA calls upon a Life Cycle Inventory (LCI) database which contains the processes and emissions associated with steps in manufacturing, transporting, and disposing a material. The LCI data on environmental impacts contain various midpoint and endpoint impacts, which notably include global warming potential and other important environmental concerns such as ozone depletion, smog formation, and micro particulate matter. The midpoint impact categories allow decisions to be made on a scientific basis, i.e. absolute measurement using mass of pollutants released. For a more user-friendliness approach, the midpoint categories may then be converted to endpoint impacts such as human health impacts, ecosystem toxicity, and natural resource depletion, which are more concise and easier to understand, and thus more meaningful to decision makers and the public.

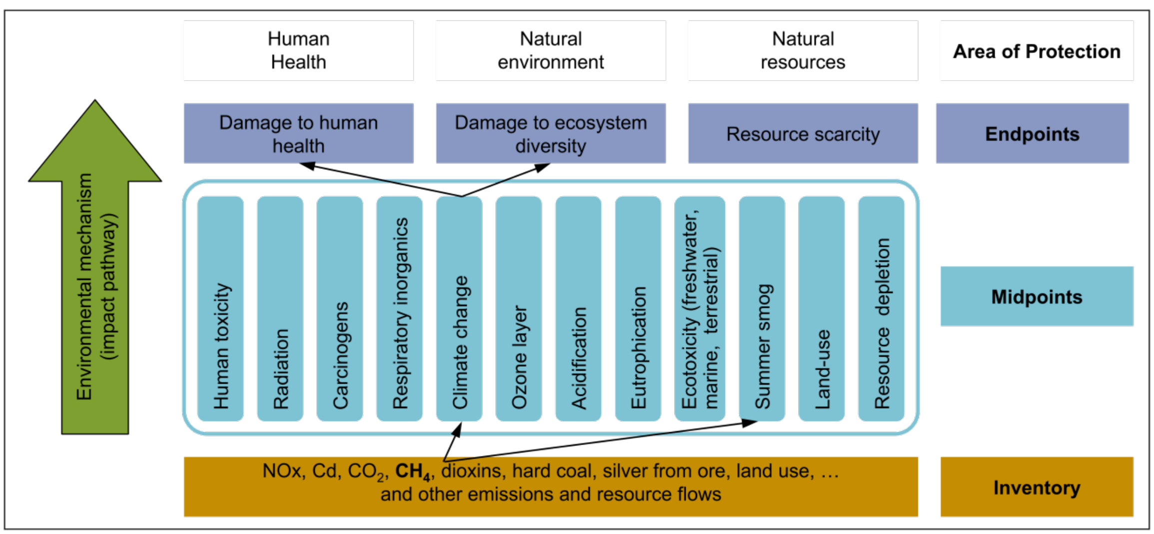

Figure 5: Life Cycle Assessment Impact Categories (European Commission, 2010)

It should be noted that the quality of a LCA is only as good as the database from which it determines the impacts. The database needs to be appropriate for the region in which the building resides. This will ensure that the impacts accurately reflect the availability of materials, transportation distance, and manufacturing processes. For North America, the standard in evaluating buildings is the Athena Impact Estimator[7] (IE).

[7] ATHENA Impact Estimator for Buildings is a software tool that is designed to evaluate whole buildings and assemblies and takes into account the environmental impacts of material

LCA is a tool which is able to quantify some of the intangible values surrounding the manufacturing and disposal (life cycle) of the materials used in the building, which is new to the evaluation of environmental building designs. LCA is a tool that trends towards full cycle accounting. While not all externalities are realized, many are captured within the mid and endpoint impact categories.

It has been found that LCA is not currently employed during decision making processes for development applications in the city. For rezoning requiring LEED certification, LCA is necessary only if the developer wants to pursue the prescriptive compliance path for LEED. Consideration should be given to incorporate LCA modeling into decisions regarding replacement or renovation of existing building stock, in particular heritage sensitive buildings, to evaluate the environmental merits of replacement versus renovation.

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manufacturing including resource extraction and recycled content, transportation, on-site construction, maintenance and replacement effects, demolition, and disposal.

4.0 Case Summaries

The following case summaries use LCA for a holistic life cycle environmental impact analysis to draw comparisons between retrofitting a heritage house versus new construction. Case studies were selected based on the relevancy of building typology, construction methods, age, and climate zone.

4.1. Vancouver House, Victoria BC – Dian Ross

The Vancouver House case study is a LCA carried out for a 1910 Arts and Craft house on Vancouver Street in Victoria, BC.

Figure 6: Front view from Vancouver Street (Ross & Coulson, 2008)

The Vancouver House was renovated in a heritage sensitive manner, preserving its character-defining elements, and achieved better performance than new construction which follows new building code. The house earned an EnerGuide rating of 80. The comparative analysis was modeled in Athena Impact Estimator for environmental impacts and HOT2000[8] for energy efficiency and consumption. For detailed model methodology and data, please refer to Appendix A: Vancouver House.

Additional graphs have been added to demonstrate the differences between the embodied energy approach and the avoided impacts approach.

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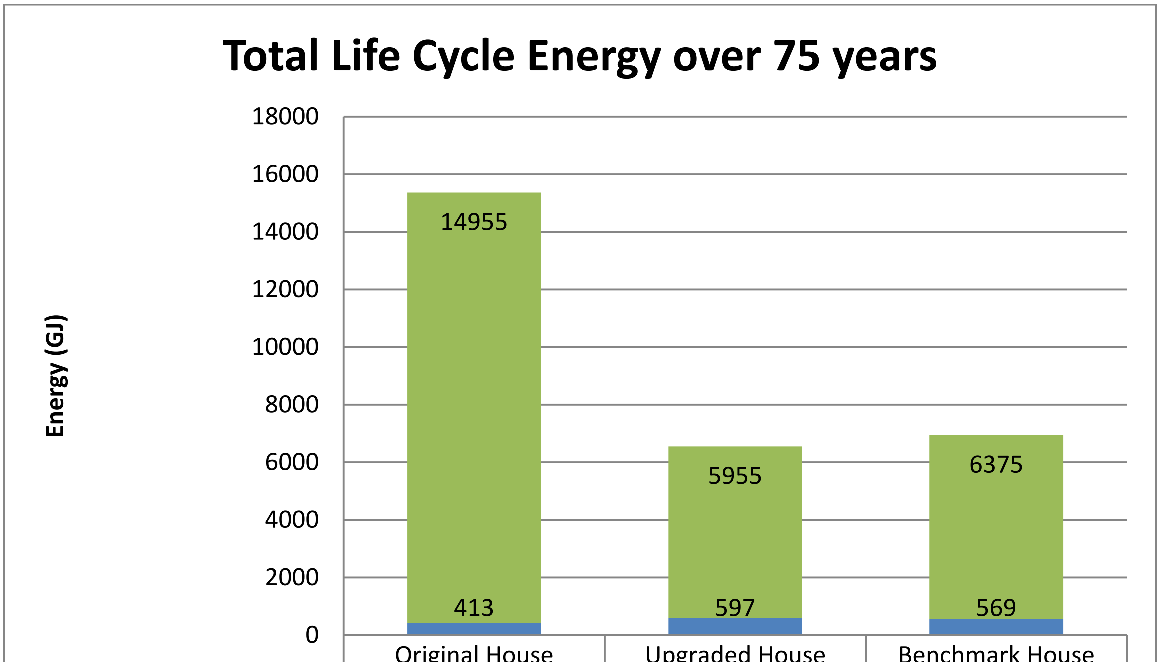
[8] HOT2000 is the Canadian standard for evaluating energy performance of houses. Developed by CanmetENERGY for North American home design professionals, it is free to use and download from Natural Resources Canada. http://www.nrcan.gc.ca/energy/software-tools/7423

The as-built renovated project was rated EnerGuide 80 (equivalent to a new house built to building code standards containing energy requirements) from its original performance of EnerGuide 50 (equivalent to an older house that has not been upgraded). The benchmark house was modeled for a theoretical new construction that followed building codes for an equivalent house. The benchmark construction received an EnerGuide rating of 74.

4.1.1. Embodied Energy Results

Total embodied energy was calculated and compared for continued operation of original house, original house with upgrades, and benchmark new construction. The results are summarized in Figure 7. These calculations for embodied energy are for a house with a hypothetical life of 75 years and include typical replacement cycles and maintenance of building products. The upgraded house scenario is a standalone evaluation of the “upgraded” building, which includes assemblies present in the upgraded house only.



	Original House	Upgraded House	Benchmark House
Operational Energy (GJ)	14955	5955	6375
Embodied Energy (GJ)	413	597	569

Figure 7 Life Cycle Energy of Original - Historic with no upgrades, Upgraded - Historic with upgrades, and Benchmark - New construction built to code

The results show that the lowest embodied energy for the life cycle including operations and construction is the upgraded house scenario, which consumes less than half of the original operational energy and also less than the benchmark new construction .

4.1.2. Incremental and Avoided Impacts

The modeled data was also used to visualize the incremental energy. The difference between the incremental energy and benchmark new construction is the impact avoided through reusing the existing structure.

The incremental impacts are calculated according to Equation 1: Incremental Impacts Equation. Figure 8: Normalized Incremental Impacts shows that renovation is only fractional compared to new construction.

Equation 1: Incremental Impacts Equation

$$\begin{aligned} &\mathit{Impacts\ of\ Upgraded\ House} - \mathit{Impacts\ of\ Benchmark\ New\ Construction} \\ &= \mathit{Incremental\ Impacts\ of\ Renovation} \end{aligned}$$

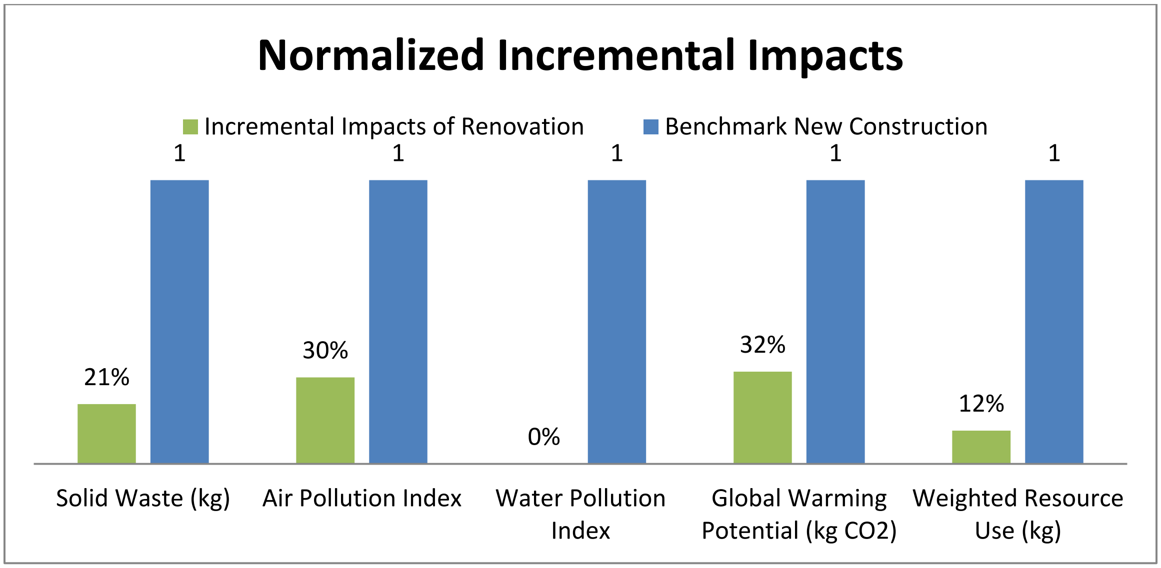


Figure 8: Normalized Incremental Impacts

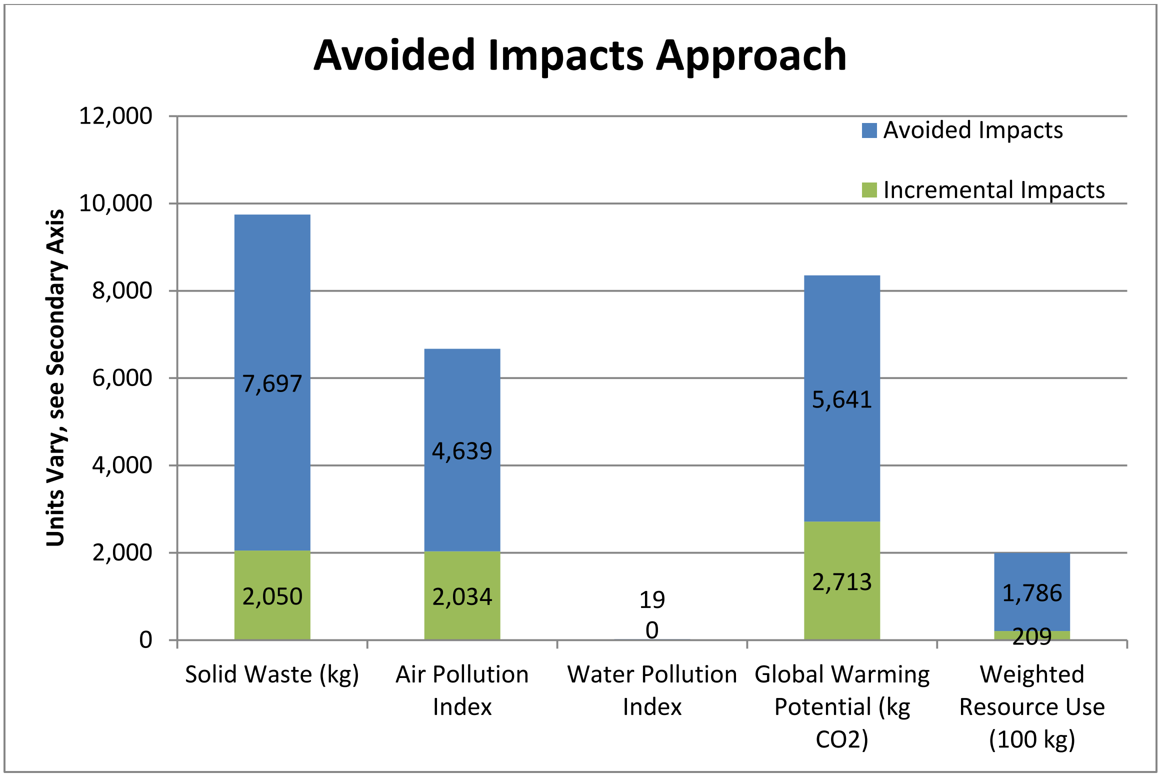


Figure 9: Avoided Impacts

Figure 9: Avoided Impacts, shows the amount of impacts that was avoided by choosing renovation over new construction in the top bar. The savings were 5.6 tonnes of GHG emissions.

4.1.3. Project Delivery

The renovation was delivered through an Integrated Design Process/ Integrated Project Delivery. The General Contractor (GC) was David Coulson Design Ltd., who served as both the design consultant and site constructor. This selection was key to the success of the project as it facilitated early and constant dialogue throughout the design build.

The Integrated Design Process is a relatively new project delivery method that brings together the GC, designer, engineer, and owner early in the project to improve the accuracy of decisions to obtain group buy-in. This process, when compared to traditional project delivery methods, shifts more of the work towards the initial design and development phase, improves value to the project owner and mitigates risk.

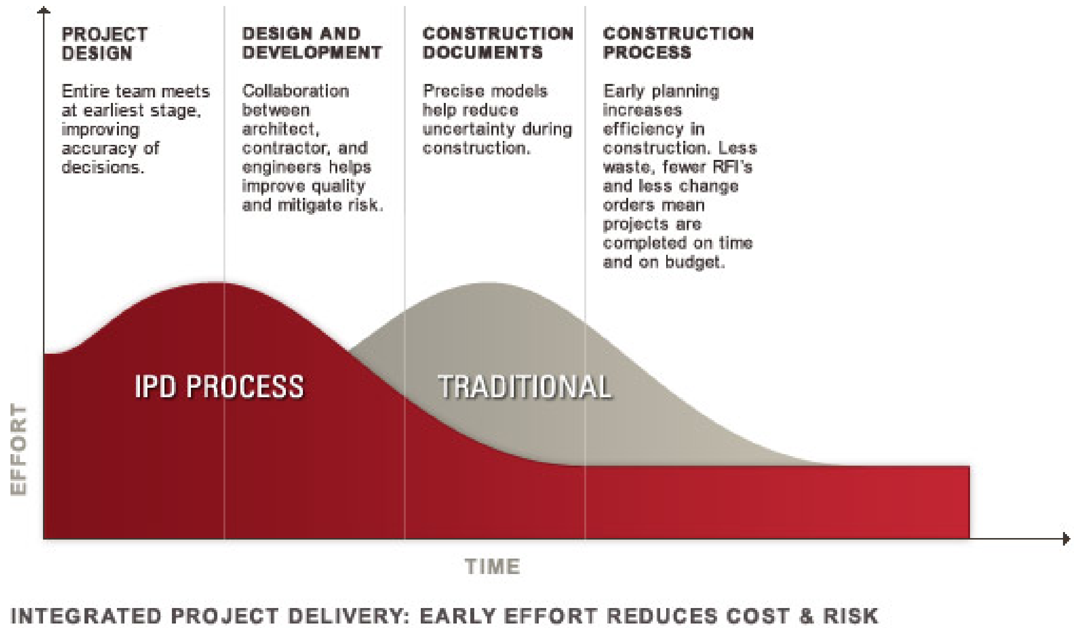


Figure 10: Integrated Project Delivery[9]

For heritage buildings, minimizing project risk during delivery is important to protect character-defining elements during the construction phase. When installing energy efficient measures, good project delivery will ensure that contractors and workforce understand the aims of the project and the heritage sensitive elements.

The full case may be found in Appendix A: Vancouver House Case Study.

[9] Source: http://www.sequoyah.com/media/11.01_.05_IPD_Graph_.jpg

4.2. Life Cycle Assessment of Heritage Rehabilitation Retrofit Scenarios – Quantis LCA

Quantis Life Cycle Assessment Consultants compared new construction (NC) vs. rehabilitation & retrofit (RR) for two detached single family residences in Portland Oregon. (Quantis, 2012)

The NC house was built in 2011, and the RR for the historical house was completed in 2009. In an effort to normalize the two buildings in order to draw fair comparative assertions, the study used buildings that share similar glazing ratios, square footage, and building programming. For energy modeling, ASHRAE Climate Zone 5 for Chicago was used to parallel climate in Vancouver.

A summary of the building programming and characteristics is presented in Table 1: Single-Family Residence Information for Quantis Study.

Table 1: Single-Family Residence Information for Quantis Study (Selection, 2011)

Single-Family Residence

	NEW CONSTRUCTION	REHABILITATION and RETROFIT
Building name	SW 34th Street	2373 NW Pettygrove
Location	Portland, OR	Portland, OR
Year built	2011 targeted	1896
Year renovated	N/A	2009
Building height	2-story	2-story
Space Summary		
Square footage	2,360	2,479
Building program elements	3 bedroom, 2.5 bathrooms, below-grade partial basement	3 bedroom, 2.5 bathrooms, below-grade finished basement
Renovation description	N/A	Added master bath and basement bath, kitchen expansion
Normalization	N/A	N/A
Core & Shell		
Structure type	Dimensional lumber, prefab truss system	Dimensional lumber
Envelope	2x6 wood framing, batt insulation, wood windows, cedar shingle roofing	2x4 wood framing, batt insulation, wood windows, asphalt roofing
Cladding	Cedar shingle	Cedar lap
% Glazing (window: wall)	18%	14%
HVAC system	Gas furnace, air conditioning unit	Gas furnace
Interior		
Type	Custom	Custom
Scope	Granite countertops, wood paneling, carpet, ceramic and wood flooring	Granite countertops, wood paneling, carpet and wood flooring

Two Energy Use Intensity (EUI) scenarios were modeled for both the New Construction (NC) and Rehabilitation & Retrofit (RR) cases. Distinct packages of Energy Efficiency Measures (EEM) were applied to both NC and RR to simulate a base case of standard energy performance at 148 kWh/m^2, RR and NC, and an advanced case of energy performance at 126 kWh/m2, Advanced RR and Advanced NC. (Quantis, 2012)

The spider chart in Figure 11 illustrates the trade-offs in various impact categories for each of the four scenarios. It can be seen that the base case heritage RR outperforms base case NC in all categories and is almost on par with advanced case NC.

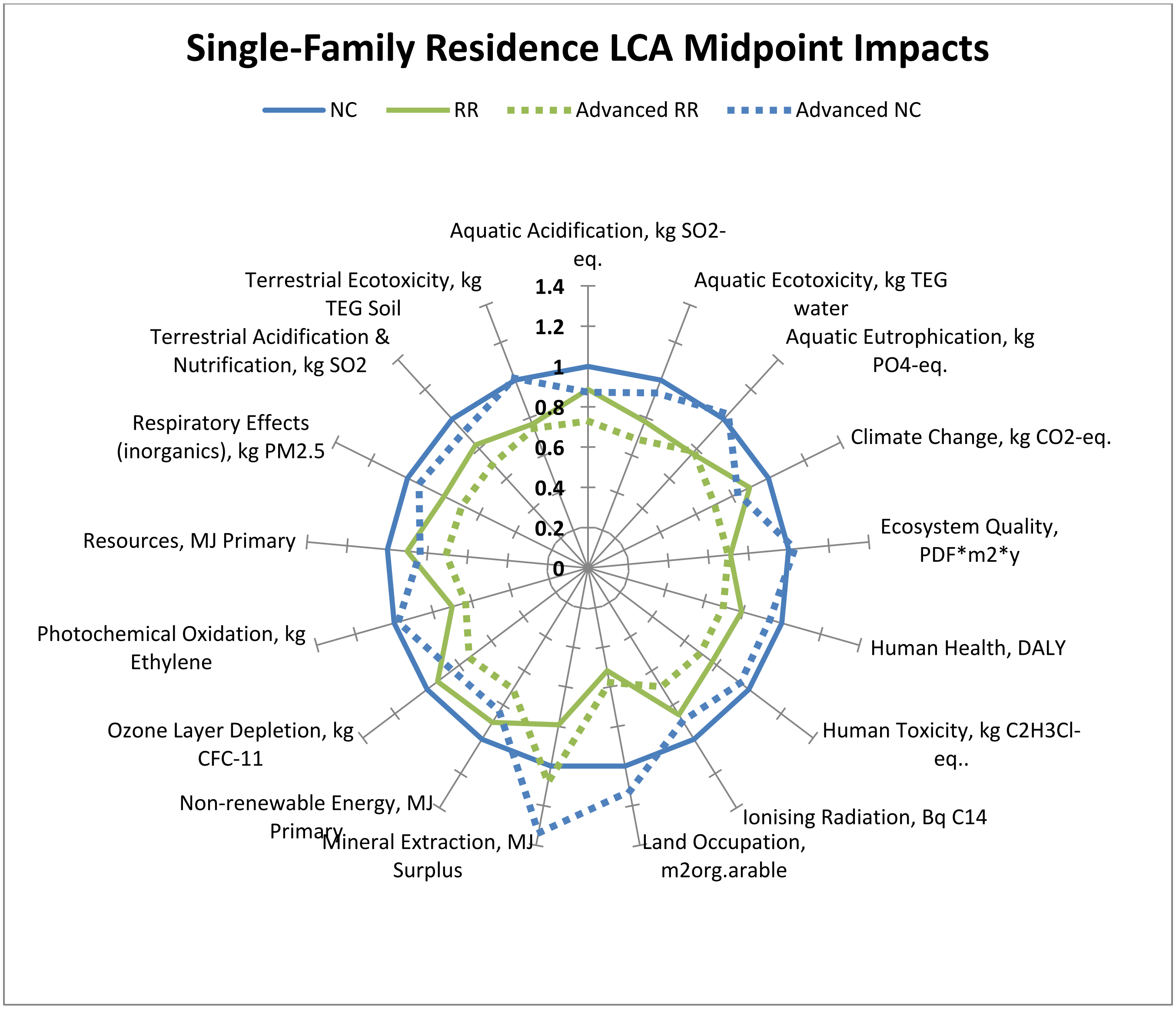


Figure 11: Spider Graph Normalized to Base Case New Construction

Table 2: Comparison of Favorability of New Construction vs. Rehabilitation & Retrofit shows that RR of a heritage house is always more favorable than NC under both the base case and advanced case scenarios. Furthermore, for the same advanced energy performance, NC does not break even for 38 years, whereas upgrading a heritage house to advanced performance only require 3 years of operations to become net positive.

Table 2: Comparison of Favorability of New Construction vs. Rehabilitation & Retrofit (Quantis, 2012)

CHICAGO			
NC Base Case *is more favorable than...*	*At a lifetime of...*	***RR Base Case*** *is more favorable than...*	*At a lifetime of...*
Climate change			
RR Base Case	(never)	NC Base Case	(always)
RR Advanced	(never)	NC Advanced	< 38 years
NC Advanced	< 4 years	RR Advanced	< 3 years
Resources			
RR Base Case	(never)	NC Base Case	(always)
RR Advanced	(never)	NC Advanced	< 39 years
NC Advanced	< 6 years	RR Advanced	< 3 years
Ecosystem quality			
RR Base Case	(never)	NC Base Case	(always)
RR Advanced	(never)	NC Advanced	(always)
NC Advanced	(always)	RR Advanced	< 56 years
Human health			
RR Base Case	(never)	NC Base Case	(always)
RR Advanced	(never)	NC Advanced	(always)
NC Advanced	< 26 years	RR Advanced	< 16 years

The Quantis study demonstrates that the environmental benefits of improving building performance is a function of the expected building lifetime, materials required for upgrades, and actual energy savings attained. In some NC cases, environmental benefits gained from energy efficiencies may be lost in the short term by the impacts caused by material-related requirements and may take decades to reach sufficient savings. In the case of single family houses, NC consumes the equivalent of 35 years in operational energy *more* than RR to achieve the same energy performance.

The next section will discuss appropriate upgrades for heritage buildings to achieve better environmental performance and heritage conservation as well as the conservation of their heritage features.

5.0 Heritage Building Performance Upgrades

The following categories of interventions were selected on the basis of heritage significance, presence of key character-defining elements, and energy saving potential.

Performance upgrades in heritage buildings should follow the general rule that key features should not be compromised when energy savings can be achieved through other reversible means. Often, the most practical solution also has the best balance of energy savings, heritage conservation, and cost.

Large adaptations or enlargement projects offer the best opportunity for retrofitting energy efficiency measures though smaller, more targeted measures may be suitable when the building is undergoing a minor adaptation.

5.1. Walls and Roof

It is important to first determine where the most energy is being wasted, either through thermal imagining, which displays the surface temperature of the building, or air pressure testing. These tests may be useful in identifying cold air intrusion and thermal imaging could help identify thermal bridging[10] and areas of missing insulation. Figure 12: Cold air leaking through behind window trim shows how a thermal imaging camera can detect cold air intrusion through the building.(Alter, 2014)

Air-sealing and insulating can usually be completed without compromising a building's historic value. They are therefore the most important interventions that should be completed prior to upgrading any other aspects of a heritage building. Air-sealing and insulation upgrades are safe for heritage houses if ventilation improvements are also planned. (Prince's Regeneration Trust, 2010)

Air sealing can be considered a "preservation" approach to greening a heritage building and a "must-do" upgrade because it is inexpensive and highly effective. In Figure 12, it is observed through the thermal image that freezing air is leaking behind the window trim, despite the window's perfect performance. It is for this reason that when addressing energy conservation matters in heritage buildings, the lowest impact measures must be completed first, or else there would be no benefit in improving more heritage sensitive features such as windows. Figure 13 shows a replacement steel door installed with poor air-sealing. Without proper installation and air-sealing, replacing windows and doors in the name of high performance may be counterproductive. (Prince's Regeneration Trust, 2010; US EPA, OSWER, & Office of Brownfields and Land Revitalization, 2009)

[10] Thermal bridges occur where insulation is not continuous and causes heat loss, such as along the stud of a wall.

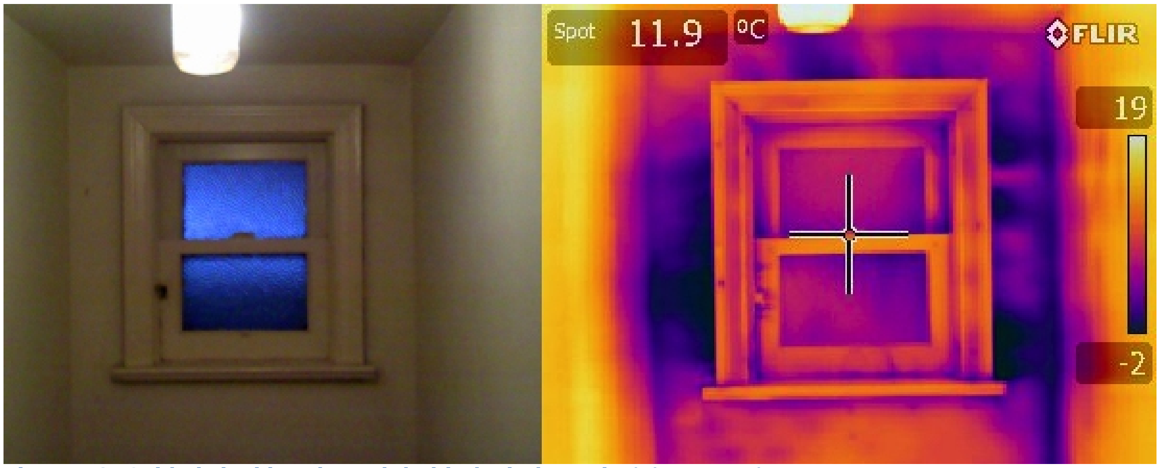


Figure 12: Cold air leaking through behind window trim(Alter, 2014)

Figure 13: Cold air leaking above well insulated door (Alter, 2014)

While reducing the number of air exchanges through air tightness improvements is desired, historical houses are not designed for the same air tight designs to which modern buildings aspire. Natural ventilation in high moisture areas of the building, such as the kitchen and bathroom, allow the dissipation of moisture. Leakage can be safely reduced through preventative steps during installation such as fitting roof vents without visual impacts from key vantage points.(US EPA et al., 2009)

5.1.1. Insulation

To avoid damaging any historic fabric, insulation should begin with the pipework, valves, boilers, and hot-water cylinders, followed by roofs. Roof insulation is extremely cost effective and can reduce CO_2 emissions by a quarter in some cases. For wall insulation, the impact of the retrofit measure depends on the type of insulation and the associated intervention. (Prince's Regeneration Trust, 2010)

Blown cellulose insulation typically has an R-value of 3.8/in and can be blown into attics and walls. This can be classified as a "preservation" approach as no major deconstruction is required to install this insulation. Care should be taken to ensure that access holes do not harm the character-defining elements of the building. Loose fill cellulose is a very sustainable material, since it is recycled from old newspapers, moderates air infiltration, and has a capacity to buffer moisture. Other batt insulation, including lamb's wool and recycled cotton, are also good choices as the fabric can still breathe and buffer moisture without impairing performance. Man-made materials, such as fiberglass, trap moisture but are significantly cheaper and acceptable if installed and monitored carefully. (Prince's Regeneration Trust, 2010; US EPA et al., 2009)

5.2. Chimneys

A chimney damper or balloon may be inserted into the flue to reduce heat loss and improve air-tightness. This is a reversible seasonal measure.(Ross & Coulson, 2008)

5.3. Windows

Windows often have significant functional and character value to a house. For "preservation" approaches to greening windows, the simplest course of action is to maintain the windows with fresh paint and ensure that the windows are well seated and sealed in the building envelope. This allows the windows to achieve the best performance in-situ. (Prince's Regeneration Trust, 2010) Restoration or repair of missing or stuck shutters can both enhance heritage character and reduce drafts and heat loss.

Rehabilitation approaches to window treatment include the installation of interior storm windows and surface films to control infra-red radiation and heat gain. Different films may be applied in different parts of the building to control solar gains and heat loss, depending on the orientation of the windows. (US EPA et al., 2009)

In some cases, double glazed panes may also be installed in existing frames if the frames can accommodate the thickness. Double glazed glass units improve the U-value of the window. However, double glazed units have a finite lifetime and for historic buildings with low glazing ratios, the savings are not as significant and may not be worth the trade-off in heritage character. Often it is found that when single laminated glazing is used in conjunction with storm windows, the thermal and acoustic benefits are on par with double glazing. (Prince's Regeneration Trust, 2010)

5.4. Heating Systems

Energy efficiency in a building can be improved through either reducing heat loss or reducing energy required to create heat through heating system upgrades. Heating system upgrades are important for heritage buildings due to their low aesthetic impacts and good energy savings.

Boiler upgrades and sizing should be done after reducing the thermal demand of the building to avoid oversizing. Upgrading the boiler to a condensing model which recycles heat that otherwise would be lost and increase efficiency, with the best condensing boilers up to 98% efficient. Replacing the boiler should not have an adverse effect on the heritage character of the building if the diameters of service holes are minimized to avoid damaging plasterwork or ceilings.(Prince's Regeneration Trust, 2010)

Air-source heat pumps can also serve as a primary heating system. Compared with conventional electrical systems, heat pumps can produce up to 4 units of heat for every 1 unit of electricity. Air-source heat pumps are well suited for climates that do not experience extended periods of sub-freezing temperatures and is ideal for Vancouver climate. Programmable controls allow home owners to optimize energy savings and there is no need to disrupt interior spaces for special ductwork.(Mutrie & Branch, 2008)

Upgrading to hydronic radiant floor heating is a sound investment in conjunction with other water heating systems, such as solar hot water, discussed in the next section, and conserves energy by heating objects through radiation and not convection of air. This system would be classified as a "rehabilitation" measure, as the installation would require stripping floorboards down to the sheathing. (US EPA et al., 2009)

5.5. Renewable Technologies

Rehabilitation of heritage houses are opportunities where extra costs of renewable technologies can be justified to preserve social value contained in the historic fabric of the building. With appropriate selection and installation, renewable technologies will enable historical buildings to maintain their character and increase performance to be on par or better than new construction.

Ground source heat pumps (GSHP) or earth energy systems (EES) can use the warmth stored and collected in the ground to provide heating or cooling for a building. They are suitable for large buildings and can provide a steady source of base load heat. While they require expertise to size and install, once installed they have double the lifespan of air source heat pumps and are more efficient, generating up to 6 units of heat for every unit of electricity. However, for Vancouver's urban environment, air source heat pumps may be more appropriate for small houses. (Mutrie & Branch, 2008; Prince's Regeneration Trust, 2010)

Solar hot water collectors capture the energy from the sun to heat water during the day. They work well in direct sunlight and even when there is cloud cover. The thermal energy captured may be stored in the domestic hot water tanks during the day, and augment the need for electric or natural gas heating from the boiler. This technology is ideal for houses that are occupied during the day. Solar hot water panels may be mounted on the side or rear elevations of the roof and care must be taken to not damage the structural integrity. Ideally there is a south facing roof that can accommodate a $4m^2$ installation. (Mutrie & Branch, 2008; Prince's Regeneration Trust, 2010)

6.0 Stakeholders

Decisions involving heritage buildings are inherently more complex than design decisions for new construction, as the historic fabric of the building contributes values to society beyond the conventional function of the building. The monetary value of this good enjoyed by society is borne, in part, by the building owners, although quantification of such values has been the subject of much debate among economists, policy analysts and decision makers. Nevertheless, any decision making framework that is able to quantify more values would progress decision making, thus advancing dialogue in the field of heritage conservation.

It is necessary to understand the role that various stakeholders play and their values for heritage house retrofits and improvements.

6.1. Homeowners

To communicate effectively the benefits of energy and heritage building conservation, we must recognize and communicate the values that are important to homeowners. Facts alone are not effective in prompting change and studies have found that tailoring already accepted values is much more important than facts. (Kahan et al., 2012) An important value to home owners is resale value and one major driver for home energy upgrades is improved thermal comfort, which is often called a soft benefit and not marketed. There is a need for better understanding of what homeowners want from their properties, whether it is financial payback, comfort, or safety, so that policies and incentives can be marketed towards those values. For instance, requiring disclosure of energy efficiency in home sales may prompt owners to consciously evaluate long term savings from home renovations, and tracking resale values of upgraded homes may provide additional evidence that heritage friendly energy retrofits have other positive benefits.

6.2. Communications

As previously identified in 2.1 Opportunities for Improvement, there is a need for collaboration between decision makers, governments, and influencers, illustrated in Figure 14, to establish policies and incentives that are beneficial to all parties.

Within the various heritage foundations, structured and regular communication is needed between groups to educate and inform of new and ongoing projects. Organized movements hold more power and would be more efficient in advancing key agenda items such as sustainability and heritage conservation.

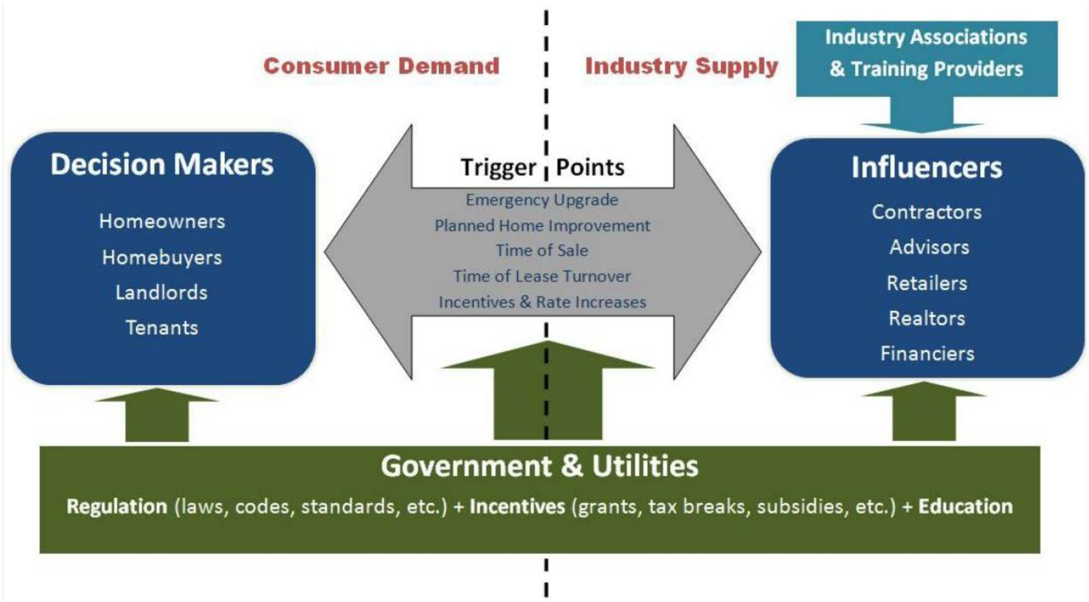


Figure 14: Market Transformation Diagram (GLOBE Advisors, 2013)

7.0 Other Benefits

7.1. Green Jobs and Economics of Heritage Conservation

Jobs created by sustainable heritage restoration may qualify as green jobs under the City's green job creation plan. Dollar for dollar, input-output economic modeling has put heritage conservation ahead of new construction in terms of local job creation and reinvestment in the local economy. (Frey, 2007)

Economic Impact per Million Dollars Invested Rehabilitation vs. New Construction				
	Residential		Non-residential	
	Rehab	New	Rehab	New
Jobs	18.4	16.4	19.3	16.7
Pers. Income	$623,000	$578,000	$685,000	$600,000
State Taxes	$120,000	$108,000	$129,000	$112,000
GDP	$937,000	$811,000	$964,000	$827,000

(Listokin and Lahr 1997)

Apart from economic models, there is a lack of specific data related to job creation from heritage conservation. There is a need for the collection and analysis of data to distinguish full-time, seasonal, and part-time employment from general employment to quantify specific job creation generated by historic rehabilitation activities. (Rypkema, Cheong, & Mason, 2011)

8.0 Conclusions

Heritage and character houses are a valuable asset not only for Vancouver's communities. The conservation of heritage and character houses also meets multiples of the city's current and emerging policy targets such as the Heritage Action Plan and Greenest City Action Plan, which include heritage conservation, GHG reduction, and landfill waste reduction. The 26,000 pre 1940s houses have the largest potential for GHG reductions, at 2.13 tonnes of CO_2/year/house totaling 52,000 tonnes of CO_2/year and warrant further attention to initiate incentives that both address climate change needs as well as heritage conservation.

New tools such as life cycle analysis should be required for work involving heritage rehabilitation to ensure that environmental preservation is done in a holistic manner accounting for cradle-to-grave impacts. Through case studies evaluating Vancouver-equivalent historic houses versus new construction, findings suggest that upgrading historic houses is quantifiably more environmentally friendly and can perform on par or better than new houses built following the construction code.

Furthermore, the environmental benefits of heritage conservation extend beyond GHG emission savings during operations. Impacts avoided through building reuse, in particular non-carbon impacts such as ozone depletion, waste generation, resource consumption and human health effects are often overlooked.

In addition, Integrated Design Process for project management along with the selection of reliable and knowledgeable contractors can minimize risk during the construction phase. Furthermore, the Home Energy Performance Industry report recommends the introduction of recognized certification to increase consistency amongst contractors and enhance consumer confidence to start home retrofits which will provide benefits for heritage conservation.

For heritage house retrofit measures, whole building approaches are more effective in terms of cost-benefit ratio for incentives and also heritage conservation. Ensuring that the measures which have the lowest cost, such as air sealing and insulation, are addressed first and prior to replacement of heating equipment allows for proper sizing and cost savings. Performance upgrades in heritage buildings should follow the general rule that key features should not be compromised when energy savings can be achieved through other reversible means. Often, the most practical solution is also the one with the best balance of energy savings, heritage conservation, and cost.

It is recommended that heritage stakeholders in Vancouver become more engaged and actively participate in the discussion and planning for future retrofit incentives. Heritage stakeholders may pursue opportunities identified in the Home Energy Performance plan such as certification of the weatherization industry, which is highly fragmented and inconsistent and a possible driver of consumer confidence in contractors. Heritage groups should be involved during the planning of home retrofit incentives and programs, given the large proportion of heritage building stock, to ensure that incentives align with traditional building methods and that inappropriate incentives are avoided such as replacement with vinyl windows.

Fringe benefits such as market value increases should not be overlooked and more data collection and research is recommended to ascertain values that are important to homeowners during the retrofit process. Green job creation and house valuation changes should be tracked for heritage related retrofit projects as there is a lack of information for analysis.

Alter, L. (2014). Why the caulking gun (and the thermal imager) are the best weapons in the war against energy waste □: TreeHugger. Retri http://www.treehugger.com/green-architecture/why-caulking-gun-best-weapon-war-against-energy-waste.html

City of Vancouver. (2012). *Greenest City 2020 Action Plan*.

Cushing, N. (2010). *Energy Efficiency in Traditionally built Homes*.

European Commission. (2010). *ILCD Handbook - General guide on LCA - Detailed guidance*. doi:10.2788/38479

Frey, P. (2007). *Making the Case Historic Preservation as Sustainable Development*.

GLOBE Advisors. (2013). *BC Homes Energy Performance Strategic Plan (2014-2019)*. Vancouver.

Hasenfus, E. L. (2013). *Measuring the Capital Energy Value in Historic Structures*. University of Pennsylvania.

Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D., & Mandel, G. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change*, *2*(10), 732–735. doi:10.1038/nclimate1547

Mutrie, M., & Branch, B. C. H. (2008). Traditional Buildings Twenty-First Century Technologies-Not Such Strange Bedfellows Table of Contents, (April).

National Trust for Historic Preservation. (2011). *The Greenest Building □: Quantifying the Environmental Value of Building Reuse*.

Parks Canada. (2010). *Standards and guidelines for the conservation of historic places in Canada □: a federal, provincial and territorial*

Prince's Regeneration Trust. (2010). *The green guide for historic buildings □: how to improve the environmental performance of listed and historic buildings.* Norwich: Stationery Office for The Prince's Regeneration Trust.

Quantis. (2012). *Quantifying the Value of Building Reuse - Life Cycle Assessment*.

Ross, D., & Coulson, E. (2008). A Case Study into How Heritage Conservation and Green Building Technology Worked Together in One Victoria Home, (November).

Rypkema, D., Cheong, C., & Mason, R. (2011). Measuring Economic Impacts of Historic Preservation, (November).

Selection, P. (2011). The Greenest Building□: Quantifying the Environmental Value of Building Reuse MATERIALS QUANTIFICATION METHODOLOGY, 7–9.

US EPA, OSWER, & Office of Brownfields and Land Revitalization. (2009). *Sustainable Solutions for Historic Houses in Northern Californiaa*.

Vancouver Heritage Foundation. (2012). *Conserving Heritage Buildings in a Green and Growing Vancouver*.

Appendix A: Vancouver House Case Study

A Case Study into How Heritage Conservation and Green Building Technology Worked Together in One Victoria Home

Prepared for the Heritage Branch of BC and the Cascadia Green Building Council Sustainability Forum

Heritage and Conservation Analysis by Erin Coulson

Technical Analysis by Dian Ross

November 2008

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Summary

The actions taken to improve this 1910 Arts and Crafts home can best be summarized by a direct quote from the *Standards and Guidelines for the Conservation of Historic Places in Canada*:

> "Complying with environmental objectives in such a manner that character-defining elements are conserved and heritage value maintained."[1]

The subject of our case study was, at the start of this rehabilitation project, a typical Fairfield bungalow with typical "old house" problems, compounded further by extreme renovations that had compromised the home's structural integrity along with its style. Once the new owners had completed the lengthy process of selecting a general contractor for the restoration, a unique collaboration began that finally saw the project move from mere repair work to a fully integrated heritage rehabilitation combined with green building upgrade. Energy-efficient improvements and systems incorporated into the rehabilitation plan enabled the house to achieve an Energuide rating of 80 points, while custom features such as in-floor heating (fed by a geothermal well) and double-pane, argon-filled, low-emissivity-coated windows (with heritage wood frames) were seamlessly worked into the final design.

At every step, the protection of character-defining elements as well as the protection of the environment were held to be top priorities by both the homeowners and contractor, *David Coulson Design Ltd.*. Given the added complexity of these priorities, extra time, effort, and expense were required at various stages of the project. The spirit of collaboration that evolved throughout the project provides a useful example of problem solving negotiation around issues connected with heritage rehabilitation and green upgrading, in addition to the example provided by specific features and upgrades that may be adopted (or adapted) by others.

This combination of restoration / rehabilitation may well serve as a model for other homeowners, builders, and planners throughout the community. For many years to come, this home will stand as a positive contribution to the ongoing movement in green building practice and responsible conservation of the built world.

[1] Environment, p.7, *Standards and Guidelines for the Conservation of Historic Places in Canada*, Parks Canada, 2003. All quotes from *S & G* will be referenced with a section name and page number from now on (see p.8 of this report).

Part I: Heritage and Conservation Analysis

Socio-Historical Profile

Location determines much of the value of real estate, and not just in our overcrowded twenty-first century neighbourhoods. "Location, location, location" resonates throughout history, particularly if we take into account that *value* is a concept not restricted to monetary measures alone.

Home owners at the turn of the century in Victoria valued healthy living, accessibility, and a balance between the frenzy of city life and the privacy of home – just as we do. By the turn of the twentieth century, completion of the CPR terminal in Vancouver had already shifted commercial focus away from the provincial capital. The city's character took a more genteel turn, and homeowners became interested in aspects of exterior environment and interior style that had had no place in the gold rush era of the mid-nineteenth century.

The famous Victoria "land boom" of 1905-1912 (Segger, Franklin: 129), which stretched until World War I, by some accounts (*This Old House*: 3), coincided with the peak of the Arts and Crafts Movement. The Arts and Crafts aesthetic manifested itself architecturally through the use of natural wood details and a deep porch surrounding the front entrance, among other features. These elements can both be found in our case study.

As evidenced by conversation with the present homeowners (see following two sections, as well as complete interview transcripts in Appendix 1), the qualities of Arts and Crafts design more than fit the needs of their twenty-first century lifestyle. These qualities are evidenced not only by the physical attributes of the house, itself, but also the contextual factors surrounding it. This building is situated in close proximity to public green spaces; it borders a large, non-commercialized city park and is within handy walking distance of the ocean and beaches. It is nestled in a desirable and established neighbourhood, known as Fairfield, and within a few blocks of an English-style high street (with shops, services, and cafes), known as Cook Street Village. It is also readily accessible to the downtown area by foot, bicycle, and public transit. The beauty of its design and the benefit of close amenities come together to make this a home worth saving.

Our case study is a typical example of the above-mentioned "building boom" in Victoria's past. The economy was strong, the Panama Canal was complete, and new residents were flooding in from all corners of the earth. Though World War I would soon bring an end to this lucrative expansion period, at that pre-war moment the growth and vitality of Victoria seemed unstoppable:

> "A typical 60 ft by 120 ft residential lot in Fairfield, which sold for $400 in 1908, was selling for $5,000 in 1912." (T.O.H.: 3)

We estimate that this house was built in 1910[2], likely by a construction company using U.S.-designed plans (the ubiquitous "California bungalow" model), and just in time for the recently-extended streetcar system to lay track along Cook Street from downtown Victoria. With this connection to the city centre assured, residents of Vancouver Street had access to the best of both worlds.

Over the past hundred years, citizens from all walks of life have made their home in this charming two-storey bungalow. The first directory listing of 1910 begins with an accountant, followed by a Depression-era salesman, post-World War II farmer, up to a female officer manager in the 1980s.[3] There is no quick and easy way to summarize the life of this house, but it can be said that it has weathered both the calamities and good fortunes of Victoria's most recent century with no small amount of grace. Its place, both social and geographical, is as much a part of its value as the painstakingly restored woodwork around its frame. And this value is as full and multi-faceted today as it was when the streetcar arrived, "brilliantly illuminated and filled with passengers".[4]

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[2] The most direct, and earliest, reference to this address in city records is the application for a plumbing permit, taken out on April 21st, 1910, by a Mr. W. Berridge. See Appendix 3.

[3] See Historical Notes – Directories in Appendix 3.

[4] From the Colonist newspaper, Feb.22, 1890. (See Ingbritson, "A Brief History of Transit…", Appendix 3.)

The Search for a General Contractor – Collaboration Begins

The couple that currently owns this Fairfield home represents both sides of Canada and, indeed, both oceans that border our country. He grew up in Vancouver and she near the Bay of Fundy, Nova Scotia. When choosing a house in Victoria, they knew from the start that one of the criteria for their new home had to be proximity to the water. They also wanted to live in a "character" house, preferably something built between 1908 and1919. They enjoy walking and wanted to be close to town. And with their young daughter just four years old when the house hunt began – safety and accessibility to a public park also made the list.

They found all of these qualities in one location. In fact, it was on their daughter's fifth birthday that they first laid eyes on the cedar-shingled Arts and Crafts bungalow not far from the beaches at Dallas Road. Despite its obvious need for repair, they were intrigued and decided to go ahead with the purchase.

Their next step was to find a general contractor who could successfully guide the restoration of their charming, but sorely dilapidated, new discovery. They were as thorough in their search for a project leader as they had been in their search for a home. Several interviews with various contractors were conducted in their effort to find the right match.

The two main criteria in their final decision to work with design builder David Coulson were his familiarity with the Arts and Crafts period and his commitment to green building practice. By the time they signed on with David Coulson Design Ltd., the owners had themselves developed some expertise in Arts and Crafts history and its specific design characteristics. As for the "green" features of the project, one homeowner included this comment when asked about their decision to make energy efficient upgrades to the house:

> "We always had the idea we would like to make improvements in terms of energy efficiency in whatever house we bought. We didn't know early on what that would look like. It got fine-tuned once we started working with David Coulson Design. It was one of the screening questions we used […] we wanted someone who knew about green building."
>
> (Correspondence, 09/11/08)

One renovation wish list consisted of 66 items and covered everything from desired repairs and insulation improvements to new offices and bathrooms, including custom water filtration systems and significant wiring capacity upgrades for associated office and entertainment technology. An additional 16 items, emailed the following week, indicate that the homeowners had really done their homework. They requested specific treatment of geothermal and photovoltaic installations and reiterated their strong interest in both seismic safety and air filtration quality control.

Throughout the project, they maintained steady communications with both David Coulson and the on-site members of his crew. Chris Whitehead and Mark Staples, site manager and finishing journeyman, respectively, have both commented that working on this project was an ongoing collaborative process that enabled them to come to know the family well. This continuous feedback exchange, which included many specific suggestions and materials sourced by both crew members and homeowners, speaks to the positive collaborative potential of such a project and may reflect the equally positive community and sustainability values shared by all involved.

Character-Defining Elements Identified from the Start

Both the homeowners and design builder agreed that protecting and reinforcing existing heritage features of this home was a top priority. These *character-defining elements* included both physical details and unique spaces within the house, all of which were successfully retained during the rehabilitation process.

Features include:

1) The front porch (including main door) described by homeowners as, “wide and welcoming […] a wonderful transition space when coming home or leaving”.[5] The door was re-hung to swing in the opposite direction – opening from the left to reveal both the character fireplace and restored main staircase. The porch was repaired to move water runoff away from the house.
2) Interior floors, wood sideboards, pocket doors, trim and other wood details were all stripped to their original wood surfaces to reflect the Arts and Crafts aesthetic. While the floors, sideboards, and staircase could be restored *in situ*, wood trim had to be carefully removed, stripped, tagged, and replaced piece by piece.
3) Wood frame windows throughout the house. Those that could be repaired and retained were kept; badly damaged units were replaced *in kind*. Where possible, leaded glass windows were also repaired with recycled vintage glass.
4) Brick fireplaces in main entry, dining room, and master bedroom. All had over-painting removed, were retrofitted with gas inserts, and decorated with hand-made Arts and Crafts styled tiles.
5) Shingling on exterior walls, open soffits, and exposed rafter tails. Everything repaired with like materials or replaced in kind.

[5] See Appendix 1 – Interviews.

Energy Efficient Upgrades Requested by Homeowners

The total package of energy efficient technologies, materials, repairs and improvements made to this house evolved over the course of the project work. In examining the final picture of energy efficiency, the *embodied energy* of this home is a factor and must include retention of the house itself. Every piece of woodwork repaired and saved is one less piece of scrap waste and carries with it not only this immediate saving, but also the embodied value and energy of all that went into making, transporting, and installing it in the first place.

Specific improvements requested by the homeowners included:

1) Insulation – as much as possible, wherever possible. Use of blown-in, soy-based insulating material improved both the heat economy and ecological footprint of the house. Notable details include the use of vapour barrier sheeting and spray foam insulation around rim joist and electrical plugs, classic leaky spots in older homes.
2) Weather-stripping and moisture-proofing, where needed. (Requested for basement.)
3) HRV system – installation and integration with in-floor heating lines, geothermal heat pump, solar hot water panels, photovoltaic panels on rooftop, etc.
4) Roof repair.
5) Foundation wall repair.
6) Window repair and/or replacement. (Low-E glazing and argon included in the final improvement.)

Standards and Guidelines for the Conservation of Historic Places in Canada – *Challenges and Successes*

It is important to clarify that this home upgrade is by no means a "textbook" conservation project. Due to the loss, damage, and deterioration resulting from drastic renovations over close to a century of use, the house had to be stripped down to its bones and rebuilt from the inside out. Fortunately, most of the original interior and exterior features were repaired and restored in this process. Arts and Crafts-era wood details, hardware, and even floor plan elements were entirely retained, while new features have been carefully integrated into secondary and non-visible spaces in order to preserve the overall character profile of the building.

Specifically, the reconstruction team followed recommended guidelines from the *Standards and Guidelines* in the removal of, "interior spaces, features and finishes […] dating from other periods" (*S & G*: Buildings, p.47). As their objective was to restore the building to its c.1910 design, subsequent additions in the form of altered walls (during the period when it was converted to a rooming house) and interior paint (covering all wood surfaces, including the main staircase and moldings) were stripped back to reveal underlying structure and materials.

In fact, according to design builder, David Coulson, the structural integrity of the home had been seriously compromised by the most recent 20-30 years of renovations, which had seen the removal of several load-bearing walls and posts. Resultant sag and misalignment of floors and walls throughout the building had to be addressed before any other work could be done. Severely buckled foundation walls (flared out at the base when project work began) were successfully straightened and reinforced during the subterranean addition of the new basement. Hurricane ties, chimney tie downs, and interior sheer walls (running both north/south and east/west) were added for stability and to meet seismic safety targets.

Where hand scraping and sanding needed to be supplemented by other means of paint removal, a *citrus*-based paint stripping solution was employed. This product was sourced by a David Coulson Design team member, and though its retail price was higher than industrial equivalents the crew found it to be both safer and more efficient to work with than the chemical alternatives.

Character wood-frame windows throughout the house were sensitively restored, where possible, and in the case of badly damaged south-facing units, replaced in kind with matching materials and, "sash and pane configuration" (*S & G*: Buildings, p.29).

Leaded glass windows were all rebuilt using recycled vintage glass; bronze-plated interior hardware was refinished, protected, and reinstalled; wood trim, floors, built-in sideboards, and pocket doors were likewise retained; and original fireplaces upstairs and down were retrofitted with gas inserts and re-clad with hand-made Arts and Crafts style tiles.

On the building exterior, the most significant additional material was in the form of replacement cedar shingles to damaged sections, particularly on the ocean-facing (south) side and around the lower foundation walls. Rotten wood was also selectively removed from soffit boards and repaired using like material (fir).

Additional dormer windows in one bedroom and bathroom change the rear façade slightly, but they are not visible from the street.

Likewise, new systems for geothermal heating, solar hot water, and Heat Recovery Ventilator (HRV) air quality control have been cleverly imbedded into the heritage structure to cause minimal damage to character-defining elements and zero visibility from either the pedestrian right-of-way or from main living spaces within the house.[6]

It should be understood, however, that all interior walls and ceilings – including original 7/8” lathe and plaster walls – were removed during this rehabilitation project. Those walls were replaced with ½” plywood and 3/8” plasterboard (to matching thickness), which provide the above-mentioned network of intersecting N/S and E/W sheer support.

Ceiling removal allowed the project team direct access beneath original fir flooring, making the installation of radiant heat lines below the sub-floor more readily accessible and efficient, and preventing an intervention that may otherwise have damaged the heritage hardwood floors which constitute one of the home’s finest features.

The landscape design, detailed in the following section of this report, incorporated a serious effort to preserve as many of the existing plantings as possible and to achieve a heritage-compatible and user-friendly green space. The outcome agreed upon by landscape designer and homeowners was that the garden would both compliment the house and enhance quality of life for the home’s occupants.

[6] RECOMMENDED: “Installing mechanical and service equipment on the roof such as […] solar collectors when required for the new use so that they are inconspicuous from the public right-of-way and do not damage or obscure character-defining elements or undermine heritage value.” (*S & G*: Buildings, p.22)

Landscape Design for a Home and Garden that Work Together

As outlined in the *Standards and Guidelines* chapter on landscape conservation, evaluation of the existing material is always step one. Both extant plantings and prevailing site and weather conditions were carefully considered before any efforts to rebuild this garden were attempted.

Landscape designer, Ulla Coulson, visited the job site one year prior to actually starting work on the garden, then twice more throughout the year during different seasons, and finally to document and inventory the existing trees and shrubs. Site evaluation included a soil analysis, which demonstrated that this lot is nestled on high-quality loam – a healthy topsoil ideally suited to most cultivation activities.

The homeowners were given a questionnaire, through which they were invited to identify specific features they wished to keep and what the overall character and purpose of the garden should be. They were also asked to include a photo survey of their favourite features. Notable requests were that a rare heritage plum tree (in poor condition at project start, subsequently recovered) and an overall theme of the cottage garden or child's "secret garden" be maintained. Both considerations were part of the final design plan.

As this site has high wind exposure on its south-east side, an original hedge was retained to the east and an arbor purpose-built on the same side to act as a wind break for the house.

One significant challenge to this component of the project was communication between the reconstruction crew and sub tradesmen. Although landscape management plans were distributed to site supervisors, details regarding green space and plantings to be protected during construction were not adequately relayed to sub trades. This breakdown in communication illustrates an important learning-curve which may have industry-wide relevance. It is not enough for designers to understand ecological best practice if their crews and short-term trade professionals do not get the message clearly.

An example of good communication and the exercise of best practices can be found in the hardscaping installment crew.[7] This team was very aware of the impact of their movements on site, so much so that they went out of their way to employ modes of transportation and installation that did not include the use of heavy machinery. Not only did they avoid damage and interference to other installations on site while they were working, they actually used log rollers to bring in heavy boulders by hand that would otherwise have required the use of a soil-compacting Bobcat or similar vehicle. Despite the site's long and narrow profile, making access and installation of large objects especially difficult, this crew was able to complete their work without incident.

[7] Strongback Labourers, based in Fernwood.

Conclusions

As indicated in the preceding sections of this report, this case study qualifies as both a **restoration** and **rehabilitation** combined. Careful reinforcement of the main envelope of the house (including the building profile from Vancouver St.'s public right-of-way), and the preservation of all interior floors and wood details meets restoration standards as laid out by the *Standards and Guidelines for the Conservation of Historic Places in Canada*. New living, office, and utility space added below ground level – as well as several energy efficient system upgrades to heating, hot water, and air circulation – may be considered rehabilitation actions. It is worth noting that even the rehabilitation has a restorative aim in the sense that the building has been returned to its original purpose – a single family dwelling of Arts and Crafts design.

The combined research and experience on the part of both the homeowners and design builder enabled this thorough revitalization to be as sensitive as possible to the historical and aesthetic legacy of the home, while meeting – and in many cases exceeding – modern standards for health, safety, and eco-friendly code compliance.

This collaborative project is an excellent case-study in combined heritage and environmental conservation. Both the challenges and successes which arose throughout this project contributed to its use as such a model. It is to be hoped that other homeowners and builders may benefit from this example in their decision-making process and in the application of both heritage and environmental conservation guidelines to existing structures.

Part II: Technical Analysis

Life Cycle Assessment Background

Life Cycle Assessments (LCAs) are used to calculate the true energy cost of a building and its total environmental impact by considering the energy usage of a building from its 'cradle to grave'. This measure includes the energy consumed during the extraction, manufacture and transportation of materials, as well as the final creation of the building. This energy is referred to as embodied energy. It forms the basis for one of the main environmental arguments for preserving existing buildings. Traditionally, most heritage or existing buildings do not rank well in 'green' building assessments. Most environmental rating systems (eg. LEED Canada) focus on the easy to measure operating energy costs of a building over the difficult to measure embodied energy costs. In addition, though these rating systems often recommend or require that new 'green' buildings be built on previously developed sites, these systems do not consider the embodied energy of the building.

As mentioned, most Life Cycle Assessments do not take into account the embodied energy of buildings. However, the Athena Sustainable Materials Institute has recently released ATHENA Software *Environmental Impact Estimator*. The Athena Institute is a not for profit organization that directs and undertakes research in conjunction with engineering firms such as Morrison Hershfield. The Athena Institute also facilitates the incorporation of environmental considerations into the building design process. The ATHENA Software *Environmental Impact Estimator* is the only software that calculates the LCA of buildings in North America. Its mandate is to consider the environmental issues associated with constructing a building equally with traditional design issues, such as cost.

The *Environmental Impact Estimator* evaluates the 'cradle to grave' life cycle of a building in terms of[8]:

1. The primary embodied energy, including calculating the 'upstream, pre-combustion' effects of creating and transporting energy.
2. Global warming potential.
3. Solid waste emissions.
4. Air and water pollutants.
5. Natural resource usage.

The ATHENA software, like other LCA methods, models the complete structure and envelope of the building (the system being considered). What differentiates the ATHENA software is that it also models maintenance and replacement effects in terms of the building type (residential, office building), location (in either Canadian or American regions), and a user defined total building lifetime. Furthermore, it calculates the

[8] Athena Institute.

conversion between operational energy to primary energy (embodied energy) and the resulting carbon dioxide emissions. Finally, the ATHENA software simulates the energy and environmental costs associated with the demolition of the building and the ensuing deposition of the building materials. More information on the Athena Institute is available on their website at http://www.athenasmi.org.

EnerGuide and HOT 2000 Background

EnerGuide for Houses is a Natural Resources Canada (NRCan) developed rating system that measures the operating energy efficiency of both new and existing houses. It rates houses on a scale of 0 to 100. A rating of 0 corresponds to major air leakage, no insulation, and very high operating energy costs; a rating of 90 to 100 corresponds to an airtight, highly insulated house that produces its own energy – a Net Zero house. This system builds upon the EnerGuide rating systems for cars and appliances that predate it.

EnerGuide Rating Chart

Type of House	Rating
Older house not upgraded	0 to 50
Upgraded old house	51 to 65
Energy-efficient upgraded old house or typical new house	66 to 74
Energy-efficient new house	75 to 79
Highly energy-efficient new house	80 to 90
An "advanced house" that uses little or no purchased energy	91 to 100

The *EnerGuide* Rating System is composed of the following stages:
1. Analysis of existing house/ new construction by an EnerGuide energy advisor.
2. Development of a list of recommended energy-saving upgrade solutions in report format by the energy advisor using the Natural Resources Canada (NRCan) software tool HOT 2000.
3. Completion of energy upgrade solutions.
4. Verification of upgrades and blower test (approximately $300) to determine the house's rating. This rating is placed on an EnerGuide label that is affixed to the house. In addition to displaying the rating, the label also provides a projected estimate of how much energy will be expended annually in terms of electrical, oil and gas usage. An energy efficiency report is also provided.

The EnerGuide for Houses rating system provides a benchmark for the energy performance of new and existing construction. The EnerGuide rating system is based upon a non-linear scale. Improving one point in EnerGuide corresponds to a 3.5 to 6.5 Giga Joule (GJ) reduction in energy consumption. The EnerGuide system takes into account location by way of heating degree days (HDDs). Consequently, achieving the same EnerGuide rating in different regions of BC corresponds to different annual energy consumptions.

The EnerGuide rating is based upon the NRCan developed computer modelling software package, HOT 2000. HOT 2000 is a simulation software that considers a building as a system, not just individual components. Based upon user inputs of building components and preset defaults, it estimates the annual energy consumption of a building by component usage, in addition to estimating the annual green house gas emissions.

For this case study analysis, the most recent version of HOT 2000 was used, version 10.31. Note that a version of this software is free to download on the NRCan website, that is fully functional with the exception of generating an EnerGuide rating. For more information, please go to the NRCan website at: http://www.oee.nrcan.gc.ca/.

The Project

The objective for this analysis was to conduct a case study of a radical residential heritage retrofit completed by David Coulson Design Ltd. This residential retrofit, a 1910 house on Vancouver Street, Victoria, BC, is intended to serve as the platform for multiple heritage, environmental and real estate-conscious initiatives. These initiatives will further the objectives of promoting best practice in the energy upgrade industry; ensure optimal and sustainable energy performance for homeowners; and reduce the energy consumption across BC.

This analysis documents the energy and seismic retrofit upgrades completed on the Vancouver Street house. Further, the analysis utilizes the methodology of Life Cycle Assessment using the Athena Sustainable Materials Institute's computer modeling package, *Environmental Impact Estimator* to determine the embodied energy component of the house. (To repeat, embodied energy is the energy consumption associated with the construction, transportation, maintenance, and end-of-life scenarios of building materials.) In addition, the theoretical annual operating energy consumption used in this analysis is based upon the HOT 2000, version 10.31, house model generated by City Green.

This project analyzes the embodied energy and annual operating energy associated with the upgraded building. It then compares these performance metrics: firstly, with the estimated embodied energy of the original house and a typical operating energy consumption of a heritage building; and secondly, with a benchmark new building of the same size and design. Note that the upgrades completed on the Vancouver Street house were not conceptualized as one large retrofit, but rather as an incremental process over a period of approximately a year and a half. As a result, energy performance analysis was not completed on the original house; for the purposes of this analysis typical performance values are assumed.

The three house models (original, benchmark and upgraded) are independently analyzed for their total energy consumption (embodied and operating energy) over a 75-year lifetime (starting in 2008). An end-of-life demolition scenario has been included in each model. In addition, the original house is modeled with a 75-year lifetime before it is upgrade; this model includes an end-of-life demolition scenario. This model is then compared to a scenario whereby the original house exists for 75 years, is demolished and replaced with a new benchmark house which then exists for 75 years before it, too, is demolished. The 75-year lifetime was chosen as being in accordance with the Athena Institute Life Cycle Assessment methodology.

Note that it was originally within the scope of this project to determine the performance rating of the upgraded Vancouver Street house in accordance with the LEED Canada building rating system. However, although a pilot program intended to inform a LEED rating system for houses was completed in May 2008, an actual rating system is not expected until 2009. The current LEED Canada rating system for new construction is designed for non-single family residential buildings; the infrastructure is too different to give an accurate representation. It is recommended that this analysis be revisited after the LEED rating system for houses has been released.

In addition, this project provides sample energy upgrade bundles in $500, $1000, and $5000 increments for future energy upgrades of older houses. These bundles place technologies into groups that are individually effective and that also augment each other in combination. Along with a set of appropriate energy upgrade guidelines for older buildings, this report is intended to be linked to the LiveSmart BC website.

Finally, a further benefit of this analysis may be to inform the next phase of the BC Building Code changes for 2010. By 2010, achieving an EnerGuide rating of 80 will likely be a compliance path. Additionally, this project may also be able to tie in with the Province of BC's $1 million, Net Zero housing pilot program as a demonstration house. Should this occur, further monitoring of the house would follow to determine the in-service performance of the energy upgrades.

Summary of Energy Upgrades

Domestic Hot Water (DHW)

- Solar panels used to produce DHW needs.

Electrical Systems

- 2 parallel electrical systems. (Allows for a future photovoltaic (solar panel) heating system and/or generator add on.)
- Modern alarm system added.
- Speaker system for entertainment purposes added.
- Wired for modern electronic equipment including CAT5, CAT6 and fibre optics.
- Kill switch on sleeping quarters floor. Allows all electrical current to be turned off at night, thereby reducing energy consumption and occupants' exposure to electromagnetic fields.

Heating

- Radiant heat (pre-wired for solar electric 12 Volt or 24 Volt). Heats objects, not air, thereby reducing heat loss due to drafts or open doors.
- Ground Source Heat Pump (GSHP). (High efficiency geothermal heating system.)
- Heat Recovery Ventilator (HRV). Fresh air cycle tied to bathroom exhaust and other vents. (No forced air.)
- Backup heating unit in the attic (powered by attic geothermal).

Insulation

- R5/inch spray soy-based polyurethane. (Highly efficient and also adds structural rigidity.)

Seismic Upgrades

- Rebar and cement reinforcements added beneath chimney and main walls. (Foundation underpinnings.)
- Engineered beams and hangers.
- Hurricane ties added between floors; iron ties added to chimneys.
- Interior sheer walls added, both East to West and North to South.

Assumptions

The Ministry of Energy Mines and Petroleum Resources, Province of British Columbia uses a different Green House Gas (GHG) emission factor than the Athena Institute and Natural Resources for calculating environmental impacts in British Columbia. The corrected factor of 52.88 tonnes/ Giga Watt hours (GWh) for electricity was applied after the simulations in order to most accurately represent the avoided impacts.

Methodology of Case Study

1. Model benchmark, original and upgraded houses in the Athena Institute *Environmental Impact Estimator* to obtain the theoretical embodied energy consumption over a 75-year lifecycle.
2. Model the upgraded house in HOT2000, version 10.31[9], to determine the house-as-a-system theoretical annual operating consumption. Use baseline values for original and benchmark house models.
3. Determine the proportional and absolute effects of embodied energy versus operating energy consumption for the three models over a 75-year lifecycle.
4. Model and compare two possible scenarios involving the construction and demolition of the three house models for their total lifetime energy consumption.
5. Evaluate the *Environmental Impact Estimator* and HOT2000 for their suitability for modeling older houses.

Step 1: *Environmental Impact Estimator* Models

The upgraded house was modeled in accordance with the measured site drawings provided by David Coulson Design Ltd, and the listed energy upgrades. Note that polystyrene spray insulation was modeled in place of polyurethrane; alkyd paint was modeled in place of clay-based paint. The original house model was derived by removing the most recent rehabilitation add-ons. The benchmark house was modeled by substituting more conventional building materials into the upgraded house's model. Specifically, batt insulation was used in place of polystyrene and gypsum was used in place of cedar cladding.

Step 2: HOT2000 Models

An extensive EnerGuide analysis of the upgraded Vancouver Street house was completed using HOT2000 by City Green. Note that an EnerGuide assessment of the original house was not completed. Since onsite testing is required to generate an EnerGuide rating, an EnerGuide rating of 50 was assumed (the top of the range for older houses not upgraded). This value is conservative in terms of projecting the total operating energy improvement associated with the upgraded house.

For the purposes of this project, the upgraded house's energy consumption was assumed to be the HOT2000 model estimated value of 79.4 GJ/year. The original house is

[9] Work completed by Niels Anthonsen, Mechanical Engineer, Certified Energy Advisor. 15 September 2008.

considered to have an incremental operating energy consumption of 120 GJ/year[10] from the upgraded house for a total of 199.4 GJ/year. The benchmark house is considered to be an EnerGuide 74[11] with an operating energy consumption[12] of 85 GJ/year.

Step 3: Comparison of Embodied Energy and Operating Energy

The *Environmental Impact Estimator* and HOT2000 results were summarized in a table and then compared individually for each house model. (See *Summary of Results* below.) The original house model compares the effects of low embodied energy with high operating energy consumption; the benchmark house compares the effects of higher embodied energy (average) with lower (average) operating energy consumption; and the upgraded house compared the highest embodied energy consumption with the lowest operating energy consumption.

Step 4: Comparison of Lifecycle Scenarios

The following two scenarios are graphically compared:

1. Original house exists for 75 years before it is Upgraded. The Upgraded house then exists for 75 years before it is demolished[13].
2. Original house exists for 75 years before it is demolished and then replaced with the benchmark house. The benchmark house exists for 75 years before it is demolished.

Step 5: Evaluation of *Environmental Impact Estimator* and HOT2000

Based upon modeling experiences during this project, the shortcomings and attributes of these rating systems are evaluated. Recommendations as to their best applications and further development are provided.

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[10] As noted, an increase of one EnerGuide point represents a 3.5GJ to 6.5 GJ annual energy reduction. The original house is conservatively assumed to have improved from EnerGuide 50 to 80 at an improvement of 4GJ per point (a total increment of 120 GJ/year.)

[11] A typical value for new construction in BC prior to the 2008 BC Building Code.

[12] Ministry of Energy, Mines and Petroleum Resources, Province of BC, *Energy Savings Spreadsheet* 2008 average house energy consumption.

[13] The demolition scenario is included in both comparison models for the sake of completeness, not because it is recommended that the houses be demolished after 150 years.

Summary of Results

Athena Institute's *Environmental Impact Estimator*

The performance metrics and the estimated annual operating energy consumption of the three house models are presented in the following tables. A proportional comparison between the embodied energy and the operating energy consumption over a lifetime of 75 years is also presented for each model.

Benchmark House

Note that due to the high upstream embodied energy of new buildings materials and an average operating energy consumption associated with common practice modern houses, the embodied energy accounts for 8% of the total lifetime energy.

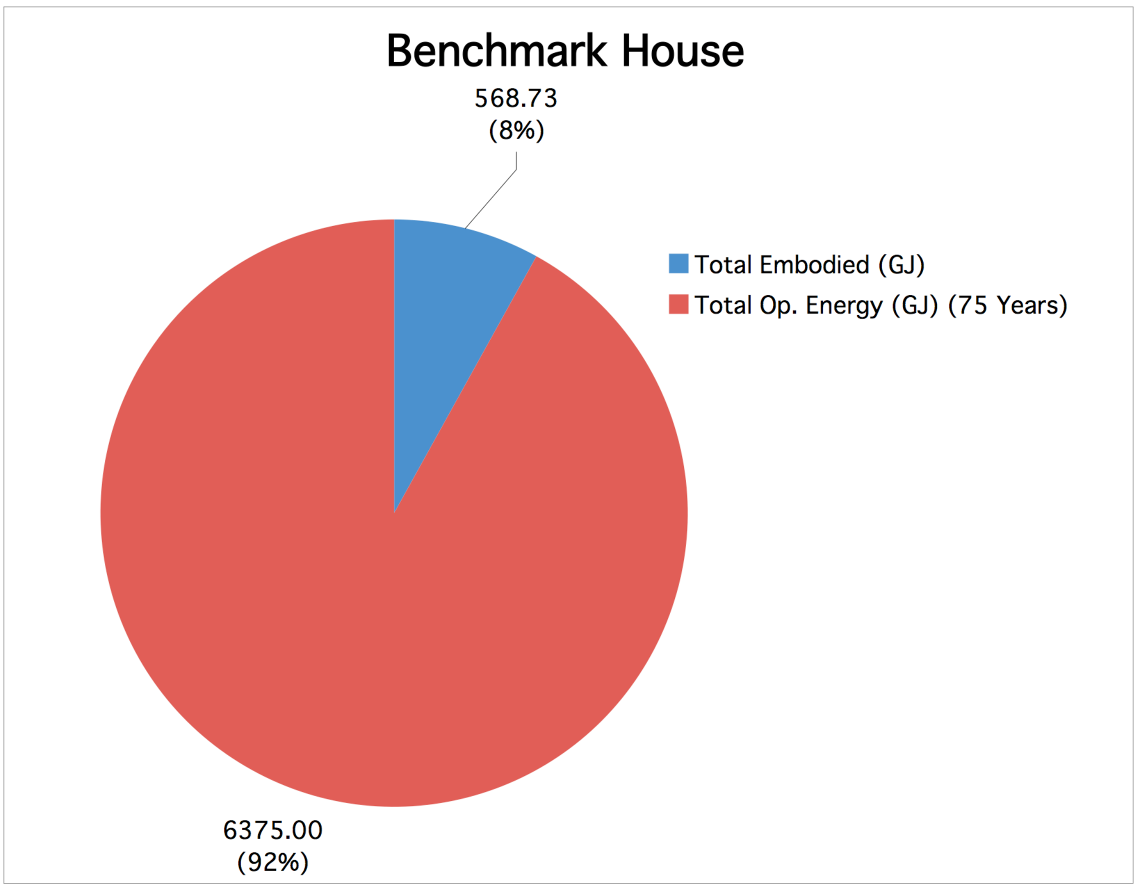


Figure 1: Benchmark House: Embodied Energy versus Operating Energy (75 years)

	Primary Energy Consumption GJ	Solid Waste kg	Air Pollution Index	Water Pollution Index	Global Warming Potential kg (corrected)	Weighted Resource Use kg
Manufacturing:						
Material:	377.906	5203	4446	18	5551.02	157493
Transportation:	9.890	0	3	0	145.27	268
Total:	387.796	5203	4449	18	5696.29	157761
Construction:						
Material:	3.319	1865	48	0	48.75	85
Transportation:	12.894	0	4	0	189.40	293
Total:	16.213	1865	52	0	238.15	378
Operations & Maintenance:						
Material:	157.645	2679	2169	1	2315.63	20511
Transportation:	3.979	0	1	0	58.45	92
Total:	161.624	2679	2170	1	2374.08	20603
End-Of-Life:						
Material:	0.027	0	1	0	0.40	1
Transportation:	3.069	0	1	0	45.08	70
Total:	3.096	0	2	0	45.48	71
Total Embodied:						
Material:	538.897	9747	6664	19	7915.80	178090
Transportation:	29.832	0	9	0	438.20	723
Total:	568.729	9747	6673	19	8354.00	178813
Operating Energy:						
Ann. Op. Energy:	85.000					
Total Op. Energy: (75 year)	6375.000					
TOTAL LIFETIME ENERGY	75 year	**6943.729**				

Table 1: ***EIE*** **Summary Measures of Benchmark House**

Original House

Note that due to the low upstream embodied energy of traditional buildings materials and the high operating energy consumption associated with older houses, the embodied energy accounts for only 3% of the total lifetime energy.

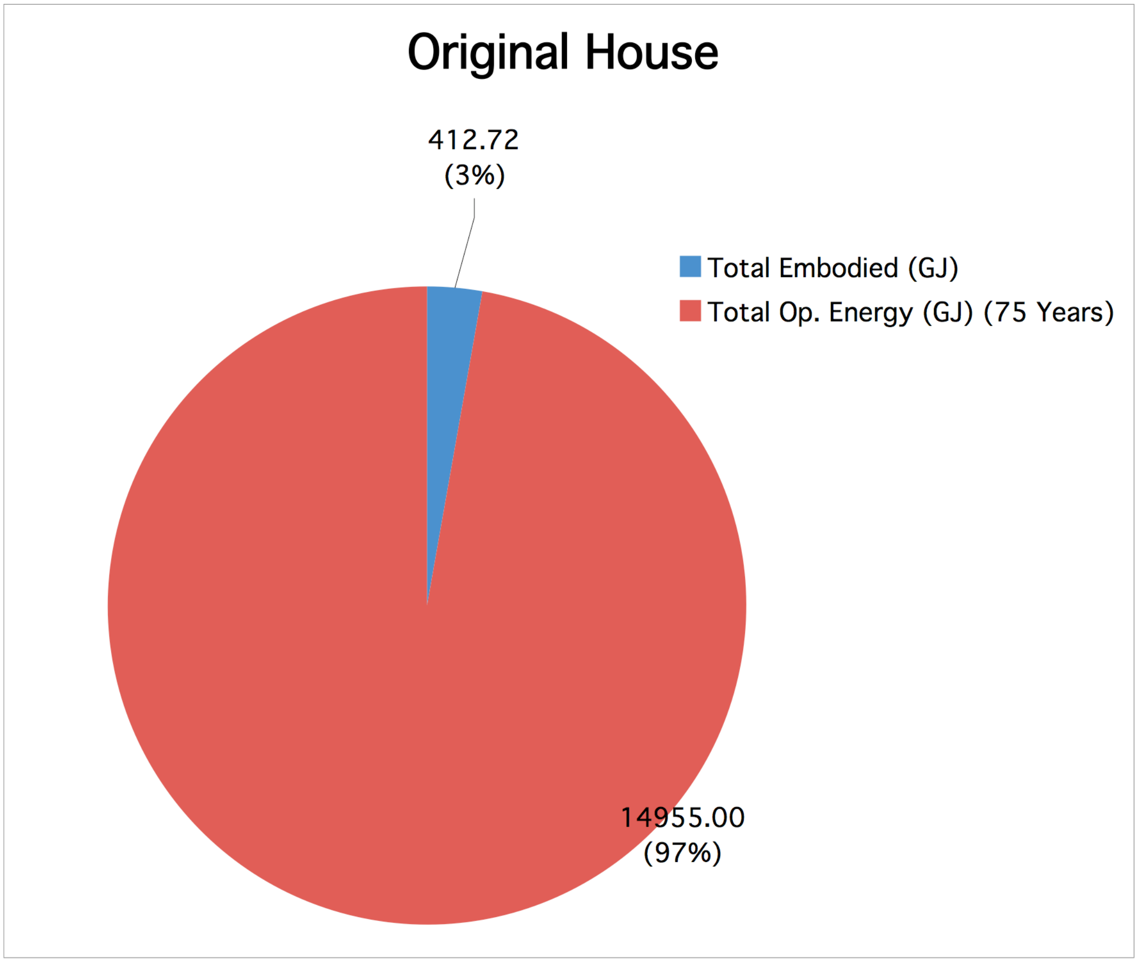


Figure 2: Original House: Embodied Energy versus Operating Energy (75 years)

	Primary Energy Consumption GJ	Solid Waste kg	Air Pollution Index	Water Pollution Index	Global Warming Potential kg (corrected)	Weighted Resource Use kg
Manufacturing:						
Material:	228.090	3156	2522	18	3350.39	136517
Transportation:	7.689	0	2	0	112.94	185
Total:	235.779	3156	2524	18	3463.33	136702
Construction:						
Material:	3.112	1810	46	0	45.71	81
Transportation:	9.937	0	3	0	145.96	225
Total:	13.049	1810	49	0	191.68	306
Operations & Maintenance:						
Material:	157.645	2679	2169	1	2315.63	20511
Transportation:	3.979	0	1	0	58.45	92
Total:	161.624	2679	2170	1	2374.08	20603
End-Of-Life:						
Material:	0.027	0	1	0	0.40	1
Transportation:	2.236	0	1	0	32.84	51
Total:	2.263	0	2	0	33.24	52
Total Embodied:						
Material:	388.874	7645	4738	19	5712.13	157110
Transportation:	23.841	0	7	0	350.20	553
Total:	**412.715**	7645	4745	19	6062.32	157663
Operating Energy:						
Ann. Op. Energy:	199.4					
Total Op. Energy: (75 year)	**14955**					
TOTAL LIFETIME ENERGY	75 year	**15367.72**				

Table 2: *EIE* Summary Measures of Original House

Upgraded House

Note that due to the high upstream embodied energy of new buildings materials and the much lower operating energy consumption due to significant energy upgrades, the embodied energy accounts for 9% of the total lifetime energy, an increase from the benchmark house model.

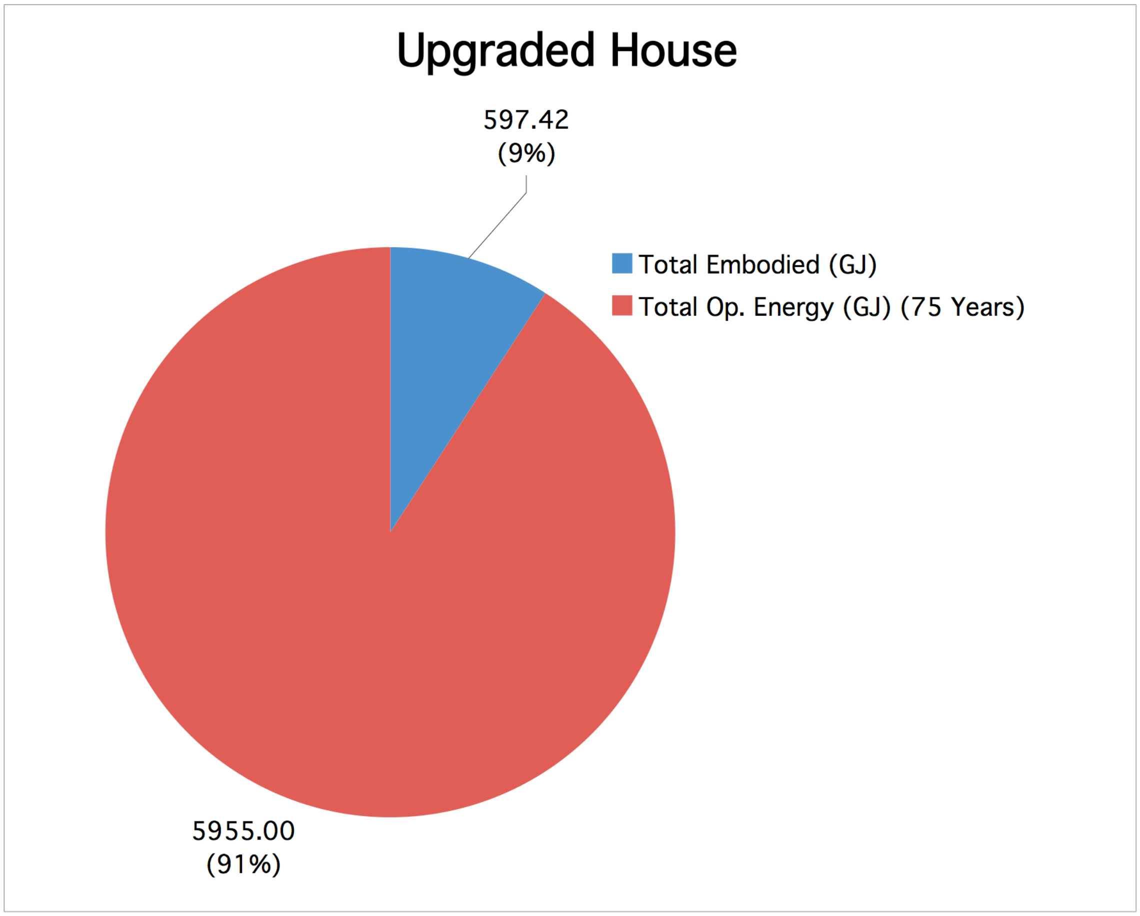


Figure 3: Upgraded House: Embodied Energy versus Operating Energy (75 years)

	Primary Energy Consumption GJ	Solid Waste kg	Air Pollution Index	Water Pollution Index	Global Warming Potential kg (corrected)	Weighted Resource Use kg
Manufacturing:						
Material:	406.984	5151	4552	18	5978.14	157283
Transportation:	9.751	0	3	0	143.23	265
Total:	416.735	5151	4555	18	6121.37	157548
Construction:						
Material:	3.319	1865	48	0	48.75	85
Transportation:	12.630	0	4	0	185.52	287
Total:	15.949	1865	52	0	234.27	372
Operations & Maintenance:						
Material:	157.645	2679	2169	1	2315.63	20511
Transportation:	3.979	0	1	0	58.45	92
Total:	161.624	2679	2170	1	2374.08	20603
End-Of-Life:						
Material:	0.027	0	1	0	0.40	1
Transportation:	3.085	0	1	0	45.32	70
Total:	3.112	0	2	0	45.71	71
Total Embodied:						
Material:	567.975	9695	6770	19	8342.92	177880
Transportation:	29.445	0	9	0	432.51	714
Total:	**597.420**	**9695**	**6779**	**19**	**8775.44**	**178594**
Operating Energy:						
Ann. Op. Energy:	79.4					
Total Op. Energy: (75 year)	5955					
Total Op. Energy: (150 year)	11910					
TOTAL LIFETIME ENERGY	75 year	**6552.42**				
TOTAL LIFETIME ENERGY	150 year	**12507.42**				

Table 3: *EIE* Summary Measures of Upgraded House

Natural Resources Canada's HOT2000

House Model	*EnerGuide Rating*[14]	*Annual Operating Energy Consumption (GJ/year)*
Benchmark	74	85
Original	50	158.4

	AS BUILT			
Annual Energy Consumption (kWh)	**Conditions 1 & 3**	**Conditions 2& 3**	**Conditions 1 & 4**	**Conditions 2 & 4**
EnerGuide Rating	80	80	84	85
Space Heating (incl. heating system fan)	12002.19	11851.15	6911.16	6754.87
Domestic Hot Water	1281.05	1007.83	1281.05	1007.99
Base Loads (minus heating system fan)	8760	8760	8760	8760
TOTAL ANNUAL ENERGY CONSUMPTION (kWh)	**22043.24**	**21618.98**	**16952.21**	**16522.86**
TOTAL ANNUAL ENERGY CONSUMPTION (GJ)	**79.4**	**77.8**	**61.0**	**59.5**

Figure 4: City Green Analysis[15] of Upgraded House

CONDITIONS
1 DHW in Mechanical Room
2 DHW inside conditioned space
3 Pilot lighted Natural Gas fireplaces
4 Spark Ignition Natural Gas fireplaces

As noted by City Green, there is a significant energy saving associated with using spark ignition as opposed to the in place pilot lighted Natural Gas fireplaces.

[14] Assumed typical values.
[15] Completed by Niels Anthonsen, Mechanical Engineer, Certified Energy Advisor. 15 September 2008.

Discussion

The combined effect of embodied and operating energy over a 75-year lifecycle is presented for the three house models – original, upgraded, and benchmark – in Figure 5. The highest energy consumption, at 15367.72 GJ, is for the original house due to its very high operating costs which dominate the low embodied energy of the traditional building materials. The benchmark house has the second highest lifecycle energy consumption at 6943.73 GJ. In this model of an average modern house, the higher embodied energy of the modern building materials contributes more significantly to the total lifecycle energy consumption. Nevertheless, the operating energy consumption is still the dominant effect over the 75-year span. Finally, the upgraded house represents the highest initial embodied energy consumption due to the high performance building materials. However, it represents the lowest total energy consumption at 6552.42 GJ.

For an increasingly efficient building (lower operating energy), the embodied energy is increasingly significant. Note that the *Environmental Impact Estimator* does not consider the embodied energy of mechanical add-ons such as the solar panel domestic hot water (DHW) heaters and ground source heat pump used in the upgraded house. However, in many instances, there is a higher upstream energy cost for downstream efficient technologies. As a result, the significance of embodied energy in the upgraded and benchmark houses is understated in this model.

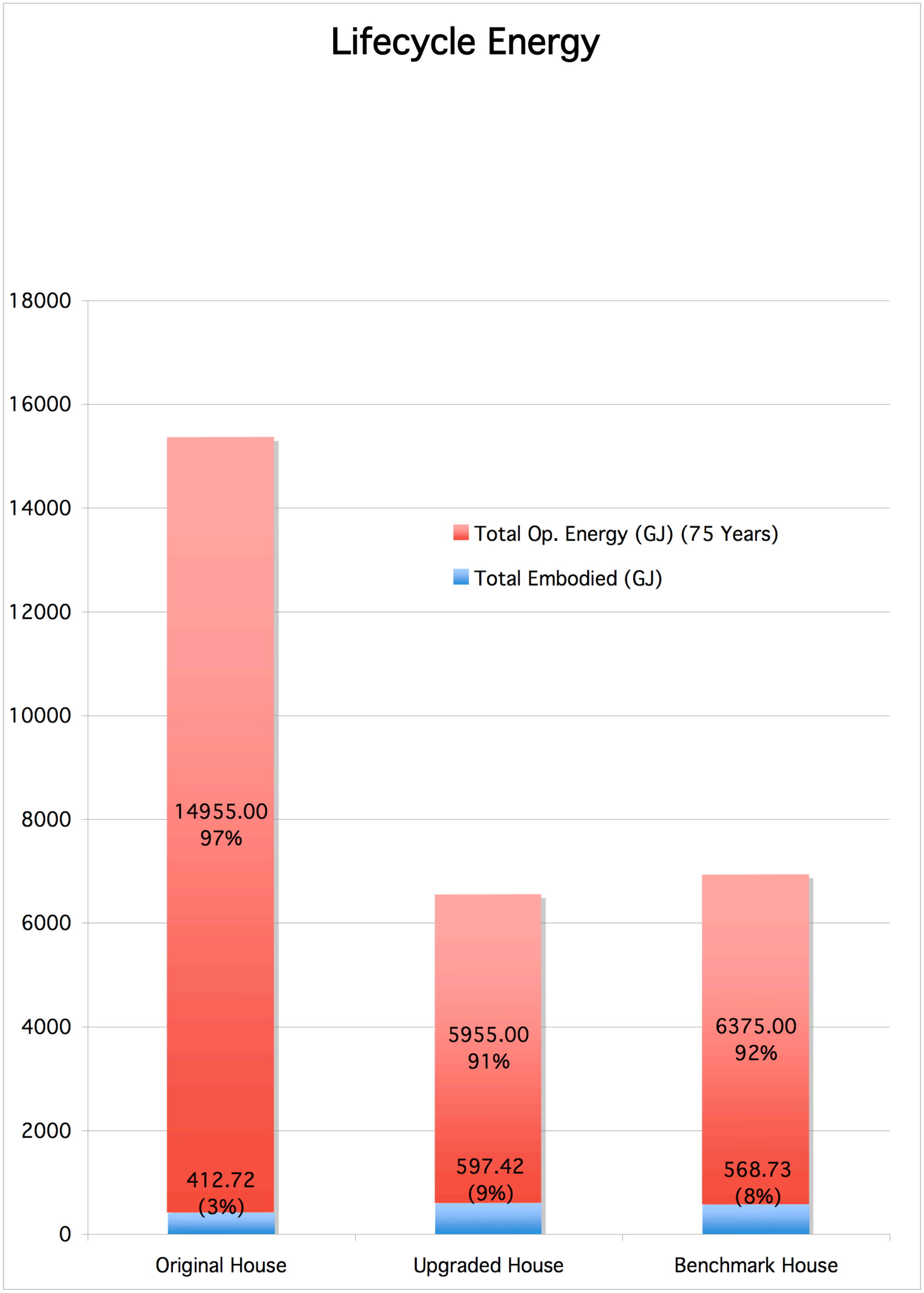


Figure 5: Lifecycle Energy Consumption for the 3 House Models

In Figure 6, the total lifecycle energy over 150 years is presented for two scenarios. The first scenario analyzed considers the original house existing for 75 years before it is demolished and replaced with the benchmark house. The benchmark house then exists for 75 years before it is demolished. The second scenario considers the original house existing for 75 years before it is upgraded. The upgraded house then exists for 75 years before it is demolished. As demonstrated in the graph, Scenario 2 saves approximately 806 GJ over the 150-year lifetime. The theoretical operating consumption of the upgraded house is approximately 79.4 GJ/year (85 GJ/year assumed for the benchmark house). As a result, this 806 GJ saving represents the operating energy consumption associated with more than 10 years of the upgraded house's lifetime. Given that the Province of BC has committed to reducing BC Hydro's demand side growth by 50% by 2020, this energy saving is considerable. As this scenario case study demonstrates, the most sustainable method of energy reduction is repairing and improving as opposed to demolishing and replacing.

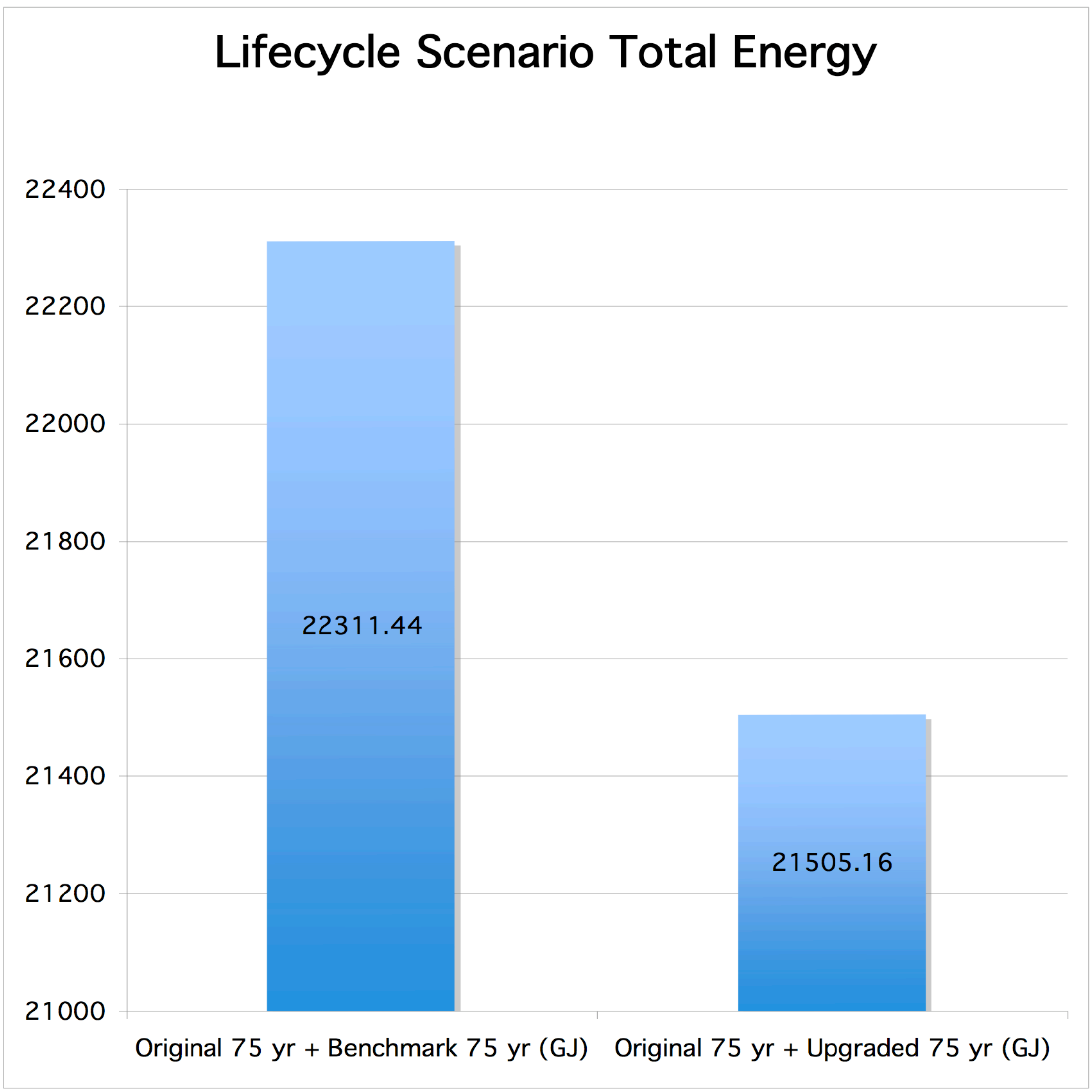


Figure 6: Lifecycle 150-year Scenario Total Energy

EnerGuide 80

Traditionally, it has not been considered possible to upgrade older, in particular heritage, buildings to modern energy efficiency standards. The Vancouver Street house has set a precedent for proving that older buildings can contribute to reducing the residential operating energy load. Natural Resources Canada considers a building with an EnerGuide rating of 80 to have an energy efficiency performance within the top 5% of the building stock. As of September 5, 2008, all new residential construction in BC must comply with new energy efficiency Building Code objects. The Vancouver Street house exceeds the alternative Building Code compliance path of achieving EnerGuide 77. Achieving EnerGuide 80 is also recognized by BC Hydro as being PowerSmart Gold. Additionally, many of the energy upgrades undertaken at theVancouver Street house are recognized by LiveSmart, the federally and provincially joined efficiency incentive program. Specifically, LiveSmart BC recognizes and provides incentives for increasing a house's overall EnerGuide rating by 40 points (LiveSmart Gold) or 20 points (LiveSmart Silver); installing a solar water heater; installing a ground source heat pump; increasing insulation; and improving air tightness. All of these upgrades are in place at the Vancouver Street house. Details of the LiveSmart program are available at www.livesmartbc.ca.

Conclusions

Athena Institute's Environmental Impact Estimator:

Although the Athena Institute *Environmental Impact Estimator (EIE)* offers many options with regards to building and structural types, there are some shortcomings. Specifically, it does not include a complete listing of Canadian cities. Victoria, BC, was not included; Vancouver, BC, was used as the closest city. The *EIE* uses the geographic location to determine the material transportation embodied energy costs associated with a given location; HOT2000 uses the weather data associated with a given location to generate an operating energy consumption estimate. As a result, Vancouver is a good geographic approximation for Victoria, although there is potentially a higher energy cost associated with transporting to Vancouver Island that is not reflected in this model.

Secondly, the *EIE* only considers the embodied energy associated with the building materials (such as wood or insulation). It does not consider the embodied energy associated with mechanical systems such as heat pumps, solar panels or heat recovery ventilators (HRVs). However, in many instances, these systems represent a greater embodied energy impact than the basic building materials. Furthermore, the mechanical systems which represent the most efficient operating energy consumption often represent the most energy intensive manufacturing processes. These upstream effects are not accounted for in either *EIE* or HOT2000.

In addition, the *EIE* does not include all building materials encountered during this project. In order to increase functionality, historic building materials such as plaster and marble should be available under the heading of "Extra Materials". Furthermore it was not possible to specify all the new materials used in the rehabilitation of this project. Specifically, clay based paints and polyurethrane (soy-based) insulation were not options; instead alkyd paint and polystyrene were modeled. However, many of the new materials used in this project were chosen for their low toxicity and environmental impact in addition to their contribution to higher operating energy efficiency. Consequently, the upgraded house may have a lower environmental impact than is stated in this report.

The *EIE* would also be more versatile if it allowed the user to specify more options, such as joist size or absolute areas, instead of presupposing a common practice values – most heritage buildings differ significantly from these values. As a result, it was necessary to finesse sizes in order to model the appropriate areas and material amounts. However, as the *EIE* is quantity based as opposed to house-as-a-system based (like HOT2000), changing the way the building structure is modeled did not effect the operating energy consumption. In addition, more user specifications would prevent the *EIE* from internally specifying modern building materials, such as gypsum, which are inaccurate for many heritage buildings.

The *EIE* does not rigorously account for the operating energy consumption of its house models. It utilizes a user defined annual operating energy consumption for its calculations. However, this information is not always known to the user but represents the majority of a house's energy consumption over its lifetime. In addition it was determined that there is a flaw in the program that miscalculates the annual operating energy consumption. As a result, the correct values were manually entered after the simulation into a spreadsheet that was used for further calculations.

Finally, there is not yet fully functionality available in the *EIE*. A natural next step would be to activate such options as interior doors and materials under "Extra Materials". Furthermore, replacing heritage windows with new vinyl or aluminium ones is often highlighted as an area in which the operating energy consumption of heritage buildings could be reduced. It would be useful if more options were added that modeled original windows and less invasive procedures, such as storm windows, that reduce the energy consumption.

Natural Resources Canada's HOT2000:

HOT2000 simulates houses as systems, but does not consider the upstream energy effects of the building materials specified. As a result, combining the results of the *EIE* and HOT2000 gives the user a more complete picture of the total lifecycle effects of a building. There were, however, some additional shortcomings identified with HOT2000.

Firstly, HOT2000 uses defaults for occupant behaviour including DHW usage and electric load. As a result, HOT2000 does not currently credit more energy efficient appliances or lighting. However, future revisions to the BC *Energy Efficiency Act*, as referenced in the BCBC, will likely regulate these energy upgrade measures and Natural Resources Canada may develop EnerGuide to incorporate the increasingly common usage of compact fluorescent lighting (CFL) and efficient appliances.

Next, an EnerGuide rating is a rounded number. HOT 2000 calculates a decimal value for the EnerGuide rating that is rounded to the nearest whole number. As a result, a house model that scored 76.4 would be considered an EnerGuide of 76, while a house that scored 76.5 would be considered an EnerGuide 77. In the HOT2000 report generated by City Green, it should be noted that in one instance, moving the mechanical systems to be within the main building envelope did not result in an EnerGuide rating improvement, but did result in an measurable energy savings.

Further to the previous point, each EnerGuide point represents a reduction of between 3.5 – 6.5 GJ. Therefore, while most upgrade measures represent a reduction in energy consumption and GHG emissions, not all upgrades result in an improvement in EnerGuide points. In addition, the higher the baseline EnerGuide rating, the more difficult it is to improve the rating.

Guidelines for Energy Upgrades of Older Houses

The home-energy upgrades listed below have demonstrated improvement to the energy performance of older houses while minimizing the level of invasion required. Consequently, these upgrades reduce costs and reduce the likelihood of incompatible energy upgrades that could cause moisture and mold problems.

Draught-proofing

Draught-proofing is the most important step. Draught-proofing can be accomplished by applying clear-drying latex caulking to cracks in walls, floor boards and around windows. This type of caulking has the advantage of being both easily removable and visually unobtrusive. A further draught-proofing method adds insulation to the underside of floor boards to reduce air leakage and improve the thermal performance. In addition, adding a radiant heat source to the under-side of the floor also reduces heat loss.

Windows

There are several methods to reduce windows heat loss without replacing the window units.

1. ***Draught-sealing windows***. Besides draft-proofing, the addition of sprung bronzed fin seal nailed on 1 inch centres also extends the life of the window by facilitating painting and maintenance of the window.
2. ***Double-glazing windows***. When the existing sash is at least 1 ¾ inch thick, a second glazing unit can be attached in front of the existing window. If installed correctly, this second glazing reduces heat loss due to air leakage and conduction through the glass. It is also possible to attach a laminated safety glass to the existing sash to improve the insulating value of the window.
3. ***Storm windows***. Exterior and interior wooden storm windows can significantly improve the thermal performance of window by reducing air leakage and by adding a thermal barrier to the existing window. When sealed correctly, the storm window can create an air barrier with the existing window that has insulating value. Storm windows, like new Energy Star windows, can be made of double or triple glazing and include low-emissivity coatings, thereby reducing heat loss.

Attic

In order to reduce the heat loss associated with attics, the following factors should be addressed.

1. ***Sealing attic hatches***. This is a significant source of heat loss due to air leakage and can often negate improvements done elsewhere in the house.
2. ***Addition of attic insulation***. Many older houses have thin walls and therefore, it is difficult to achieve significant savings by adding insulation. In addition to being a less invasive procedure, there is often more room to add insulation to the attic. As a result, it is often a more cost effective solution.

Insulation

It is possible to achieve high thermal performance (R-values) in small cavities by using new soy-based stryrene blown-in insulation. This type of insulation is more expensive, however, than traditional batt or blown insulation.

Ventilation and Exhaust

Installing a dehumidistat and an appropriate exhaust fan as a primary bathroom fan aids air quality, air movement and the reduction of moisture and pollutants. This type of system is particularly effective in electrically-heated houses.

High Efficiency Mechanical Systems

The installation of a ductless air source heat pump is a good solution for older houses. Air source heat pumps significantly improve the thermal efficiency of houses at a reasonable incremental cost. Heat pumps both cool and heat and can therefore operate year round. LiveSmart offers incentives for the installation of heat pumps. Note that air source heat pumps may not be appropriate in all regions of the province. While cold climate air source heat pumps exist, they have not yet been proven in field.

In addition, the installation of a Heat Recovery Ventilator (HRV), in combination with increased air tightness due to draught-proofing, results in significant energy savings. As with all the upgrades listed, proper installation is key to maximizing energy efficiency and minimizing adverse moisture side-effects.

Energy Bundles

Sample Energy Upgrade Bundles are outlined below. Note that these are only examples of energy upgrades broken down into three categories. Every project is unique and costs will vary accordingly.

$500 or under

- Caulking/ weatherstripping/ brass fin seals
- Attic cover hatch
- Batting insulation placed in polyethalene bag and stuffed up not-in-use chimney

$1000

- Replace single glaze panel in exterior door with wooden door. Allow for insulated slab only and optional window and new locks.

$5000 and up

- Supply and install heat pump, air conditioning line set, programmable thermostat, and low voltage wiring.
- Supply and install new air handler.

Choosing a Contractor

The Better Business Bureau (BBB) suggests to consumers that they check with the BBB before doing business with a company. However this is just one of the steps a consumer should take. All information gathered is best to have in writing: this may include a printed out email. Other steps include getting references from previous work, checking to make sure the company has all of the licensing required for that industry and making sure that they read and understand the terms and conditions of the contract including start dates and an outline of the costs of the project prior to moving forward. If there are any problems with the project the consumer has the written contract to clarify any misunderstandings.

The BBB has Reliability Reports on all companies in their database. Thecustomer experience/complaints portion of the report is based on information they have received from consumers regarding complaints theyhave processed. However, when the company is not an Accredited Business, the BBB may not have all of the necessary information consumers need to help in their decision-making.

Additionally a consumer may wish to contact The Canadian Home Builders Association (CHBA) for further information.

Glossary: Note: Natural Resources Canada: (1); ASHRAE (2)

Air Change Rate: The number of times the volume of air of one complete house is replaced by either natural or mechanical means. Measured in air changes per hour. CHMC *Glossary of Terms*.

Air Source Heat Pump (1): An air source heat pump is located outside the home and extracts heat from the ambient air and pumps it into the building.

Blower Door Test: A diagnostic test using a blower door to measure the airtightness of a building. Results are usually given in air changes per hour. Blower door tests are useful in assessing building envelopes, sizing ventilation and determining indoor air quality. CHMC *Glossary of Terms*.

Carbon dioxide (CO2) (1): A compound of carbon and oxygen formed whenever carbon is burned. Carbon dioxide causes an excess of the infrared radiation to be trapped in the atmosphere; thereby acting as a "greenhouse" having the potential to increase the surface temperature of the planet. (See Greenhouse Gas.)

Equivalent Leakage Area (1): The summation of all leaks in a building. Represents the equivalent as a hole in the building's wall with the given area.

Caulking: The process of sealing openings and leaks around windows and doors by applying an elastic, chemical mixture, generally silicone, polyurethane, or polysulfide.

Cooling degree-day (CDD) (1): A measure of how hot a location was over a period, relative to a base temperature. If the average temperature exceeds the base temperature (~18 degrees Celsius), the number of CDDs for that day is the difference between the two temperatures. However, if the average is equal to or less than the base temperature, the number of CDDs for that day is zero.

Double-paned window (1): A window containing two panes of glass separated by an air or inert gas filled space.

EnerGuide (1): A Natural Resources Canada initiative that helps consumers purchase the most energy-efficient equipment on the market. The EnerGuide label is a tool to help you make an energy-wise choice when buying a new appliance. It shows how much energy appliances consume in a year of normal service and makes it easy to compare the energy efficiency of each model to others of the same size and class.

EnerGuide for Houses (1): EnerGuide for Houses is a rating system that measures the operating energy efficiency of both new and existing houses. It rates houses on a scale of 0 to 100. A rating of 0 corresponds to major air leakage, no insulation, and very high operating energy costs; a rating of 100 corresponds to an airtight, highly insulated house that produces its own energy.

ENERGY STAR qualified product (1): An international symbol of energy efficiency, the ENERGY STAR mark helps consumers identify which appliances on the market are the most energy efficient in their class. Administered in Canada by Natural Resources Canada, the ENERGY STAR symbol is used mainly to identify products offering premium performance levels in energy efficiency. The ENERGY STAR symbol can be found on product packaging, literature and advertising and on the products themselves. In some cases, you may also find it on the EnerGuide label.

Giga Joule (GJ) (1): One gigajoule equals 10^9 joules. A joule is the international unit of measure of energy – the energy produced by the power of one watt flowing for a second.

Gigawatt-hour (GWh): One gigawatt-hour is equivalent to 10^9 watt-hours. Please see kilowatt-hour.

Greenfield site (2): A site of which 30% or less has been previously developed with impervious surfaces.

Ground Source Heat Pump: A ground source heat pump is a horizontal or vertical coil loop system that extracts heat from the earth.

Heating degree-day (HDD) (1): A measure of how cold a location was over a period, relative to a base temperature. The base temperature is 18.0°C and the period is one year. If the daily average temperature is below the base temperature, the number of heating degree- days for that day is the difference between the two temperatures. However, if the daily average temperature is equal to or higher than the base temperature, the number of heating degree-days for that day is zero.

Heat Recovery Ventilator (HRV): A device that supplies and exhausts air equally through separate air streams. Recovered heat from the exhaust air is transferred (by natural conduction) to the fresh air stream to preheat the incoming cold fresh air.

HOT2000 (1): Used by Certified Energy Advisors and other developers to determine a energy efficiency of a given house. Models a house based upon physical parameters, key component types, and location. Calculates the amount of energy the modeled house will consume annually.

Kilowatt-hour (kWh) (1):
The commercial unit of electricity energy equivalent to 1000 watt-hours. A kilowatt-hour can best be visualized as the amount of electricity consumed by ten 100-watt bulbs burning for an hour. One kilowatt-hour equals 3.6 million joules (*see* Watt).

Low-E coating (1): Low-E (low-emissivity) coatings are highly reflective, transparent coatings applied to windowpanes to slow heat loss.

Net Zero Housing: Net-Zero Housing is an international concept that describes the ability of a house to produce an annual output of energy that is equal to the annual amount of purchased energy. Related concepts include Passive Housing and Equilibrium Housing. In British Columbia, BC Hydro has recently instated a net metering program that will allow customers who produce their own power to sell back to the grid, thereby potentially achieving net zero annual energy consumption.

Photovoltaic System: A device that directly converts sunlight into electricity. When light energy strikes the surface of a photovoltaic device, a direct current is created and can be stored in batteries. CHMC *Glossary of Terms*.

R-value: A measure of the thermal resistance of a component. RSI is the Metric unit while R is the Imperial and U.S. unit. In HOT 2000, R-value incorporates air films, thermal bridging (due to framing members) and for ceiling structures insulation compression at the attic eaves.

Radiant Heating: A heating system in which only the heat radiated from panels is effective in providing the heating requirements, so that only objects, not the air, are heated. This system can be installed in the ceiling, the floor or the walls. CHMC *Glossary of Terms*.

Sheathing: A protective layer that covers the exterior of a wall or roof and provides strength to the structure.

Space heating (1): The use of mechanical equipment to heat all or part of a building. Includes the principal space heating unit and any supplementary equipment.

Storm window (1): A full-width window, either fixed or movable, installed on the interior or exterior of a window for protection against inclement weather. It is usually equipped with a single pane to reduce air leakage. Interior storm windows are usually a plastic film applied to the interior side of the window. Exterior storm windows act as a reinforced, second set of window glazing on the exterior side of the window.

Watt (W) (1): A measure of power. For example, a 40-watt light bulb uses 40 watts of electricity (*see* Kilowatt-hour).

Weather-stripping: A strip of material, such as fabric, plastic, rubber or metal, that covers window and door openings in order to reduce air infiltration and to prevent water leakage.

Resources

1. Heritage Branch, Ministry of Tourism, Culture and the Arts, Province of British Columbia.
2. Alternative Energy Policy Branch, Ministry of Energy, Mines and Petroleum Resources, Province of British Columbia. *Energy Use in BC – V7 April 25, 2008 final* spreadsheet.
3. Ministry of Energy, Mines and Petroleum Resources, Province of British Columbia. *LiveSmart BC: Efficiency Incentive Program*. www.livesmartbc.ca.
4. Office of Energy Efficiency, Natural Resources Canada, Government of Canada. *HOT 2000 version 10.31 software*. http://oee.nrcan.gc.ca/english.
5. Athena Sustainable Materials Institute. *Environmental Impact Estimator, version 3.0.3* software. http://www.athenasmi.org.
6. City Green Solutions, Certified Energy Advisors for EnerGuide. http://www.citygreen.ca/.

APPENDIX A: Interviews

Homeowners (* The family have asked that their names to be omitted from this report for the purpose of privacy protection; however, both homeowners were extremely supportive throughout the research process.) One interview took place on July 24th at the job site (transcribed below); the other, via email – responding to the same list of questions – on September 11th (her answers are transcribed with numbers only below).

1. **Did you know you wanted to buy a *heritage* home? Why?**

Yes. Aesthetics of older homes and of the Arts and Crafts movement (including the philosophy of using local and natural materials) were important. My grandmother lived in a 1908 home in Vancouver, and I have fond memories of spending time there.

2. **Do you have a favourite feature?**

Old fir floors. Both for their rustic sensibility and for health reasons.

3. **At what point, and for what specific reason, did you decide to do an energy upgrade?**

We started with structural repair, then went to efficiency second. Wanted to focus on the basement only, at first, but ended up going more holistic.

4. **Seismic stability was also greatly improved. Any other changes or improvements that relate to the natural or geographical surroundings?**

Living close to the ocean was a critical need. I grew up in Vancouver and [my wife] comes from the Bay of Fundy, in Nova Scotia. Here, we are in very close walking distance to downtown. We are one block from Beacon Hill in two directions (south and west), which helps bring us closer to nature, and provides additional play space for our daughter (our lot is small). On the down side, our part of Victoria tends to some fog, which is not good for solar collection.

5. **Are there special characteristics of the Fairfield neighbourhood that drew you to this specific location?**

Diversity within the area – mixed income and demographics; friendly. Lots of natural shade, easy for walking, and close to bus service.

6. **The decision to retain the full-size 1910 dining room seems unique. Was this a lifestyle choice or a historical nod, or both?**

We are not using it as a dining room on a daily basis. This partially reflects on our young daughter's comfort with the greater closeness and casualness of eating at the kitchen counter. Over time, our lifestyle may change. It was certainly a very heavily used room when we held a party. It may find other uses that do not interfere with its character and furnishing as a dining room. For example, [my wife] has long anticipated enjoying winter sun on the window seat along the dining room's south-facing windows (the window seat is not original to the house, but built in a period style and location). So, I see it as a historical nod (during the general contractor selection process we made some comment to a competitor-to-David that we thought the dining room was too large, and he proposed that we move the wall between the living room and dining room to adjust that – that was one of the give-aways that he was not in alignment with our intentions).

Email correspondence:

1. When we were looking for a house to buy, I was not looking only at heritage houses. I wanted a house that felt homey and combined beauty and comfort. I wanted something with "character" but a newly constructed house would have been fine with me. [My husband] was the one who had his heart set on a heritage house. He soon realized he wanted a house that was built no earlier than 1908/9 and not later than 1919. I, of course, was pulling my hair out…how long would it take to find such a house, in good condition and in a neighbourhood we could agree on??? Well, it took nine months, and when we found something close enough…we tried hard to grab it and steel ourselves for a renovation, but we had no idea it would take so long!

   On the positive side, I had lots of time to research the period and learn about efforts of people today to restore their Arts and Crafts homes.

   One of the books that influenced me was the *Inside the Not-So-Big House* by Sarah Susanka. I was excited by how the Arts and Crafts period houses already contained so many of her ideas. And I could imagine ways to make our house even more wonderful.

2. My favourite feature of the house is its wide and welcoming front porch. It is a wonderful transition space when coming home or leaving. It is sheltered and practical. It is a great space for greeting or saying good-bye to guests.

   Secondly, I love the old windows. They let in such beautiful light and give lovely views to the green spaces around the house.

3. We always had the idea we would like to make improvements in terms of energy efficiency in whatever house we bought. We didn't know early on what that would look like. It got fine-tuned once we started working with DCD. It was one of the screening questions we used when finding a construction/renovating company: we wanted someone who knew about green building. Not someone who would be learning from scratch through our project.

4. I don't think so…I know [my husband] was especially concerned because of the clay under us and so he wanted to do all that possibly could be done.

5. This part of Fairfield is amazing—so close to downtown, so close to Beacon Hill Park, so close to the water, so close to Cook Street Village—and still relatively peaceful and quiet. We often just leave our car at home!

6. I love our dining room! I would say a historical nod of enthusiastic agreement. When I first saw the dining room I probably thought it was too formal and wished that the living room could have been the larger room… However, when I read about the Arts and Crafts philosophy and its movement against the Victorian formality of most rooms, I could understand how creating one room for a "theatrical" stage, where people can come together, to celebrate, to make room for friends and family to share food together—that is a great idea, and one that still is alive today.

   We moved here after having lived several years in a co-housing community, and one of the nicest things about the Common Room in co-housing is that you have space to get together and connect fairly regularly… and celebrate when there is an occasion.

   I am looking forward to our Thanksgiving celebration. Imagine how many have been celebrated in this room?

David Coulson, design builder, David Coulson Design Ltd.

- **What types of research were conducted before work began at 222 Vancouver St.?**

With over 25 years of experience working with Arts and Crafts buildings, we felt confident in our existing knowledge base on this subject. For example, Emily Carr House, Helmcken House, Point Ellice, and both the Craigflower School House and Manor were all among David Coulson Design's restoration projects in the Victoria area. In addition, we interviewed the homeowners at Vancouver St. and learned that they specifically wanted to eliminate recent renovations (over the last 20-30 years), to retain all exterior features, and to re-create a single family dwelling.

- **Did the findings influence your design and construction significantly?**

Well, the biggest influence on project direction was the physical evidence of just how unstable the house was to begin with. A fresh coat of paint had been applied (inside and out) just prior to purchase and this gave a very misleading impression to the homeowners at first glance. We later learned that condition was much worse than first assumed, as the usual "character sags" in an older home were in fact much more severe. When work began, we saw that this damage was the result of missing load bearing walls and posts, which had been removed during earlier renovations. Foundation walls were also severely buckled – flared out – and basically everything inside and out needed to be straightened and supported right off the top.

- **Can you provide one (or more) examples of how your team chose to *preserve* or *repair*, rather than replace a heritage element?**

Everything was repaired. We disposed of very little original material – and where replacement material was necessary, it was done "in kind". Windows were rebuilt and re-glazed using heritage glass. 95-97% of all wood trim was salvaged and reinstalled. In some places, we supplemented the trim with new – and matching – material.

- **What were the main character-defining elements in this building and what steps did you take to protect them?**

Original fireplaces – which we retrofitted with gas inserts and clad in hand-made Arts and Crafts tiles. Built-in sideboards, pocket doors, leaded glass windows, and all wood detailing. Everything was repaired and restored. The profile of the house itself was protected through our decision to dig the basement down below ground level, rather than lift the house up.

- **What was the exact treatment of exterior wood and paint?**

Extensive re-shingling on the south side and lower foundation walls. [See Mark Staples commentary]

- **How were 21st century health and safety concerns addressed?**

O% VOC paints were used throughout the home (Farrow and Ball earth-based paints). Soy-based and formaldehyde-free insulation was also applied. Citrus-based wood stripper spared both the crew, and the wood itself, from the potentially damaging effects of chemical alternatives. Considerable seismic upgrades were made – hurricane ties (mechanical seismic fasteners for all floor-to-floor locations), iron chimney tie-downs, interior sheer walls (both east/west and north/south). The building inspector said that this house was likely, "the safest wood frame building in Victoria".

- **Final comments about the "marriage" of heritage conservation with eco-friendly retrofits?**

Geothermal, which allows for radiant heat, saved us from having to cut holes into the building envelope for piping. Heritage fabric was protected as a result. That, plus the most environmental choice possible *is* to invest work into an older home, rather than build from scratch. "The greenest building is the one still standing." I believe that.

Chris Whitehead, site manager, David Coulson Design Ltd.

Comments were attached to photographs taken on site by Chris during the 1.5 year project (September, 2006-May, 2008).

- no footing was found under the chimney; the team added rebar and cement reinforcements beneath chimney and main walls
- dining room restored in full in its original location – an unusual choice by today's standards, where the living room often takes precedence
- original knob and tube wiring positions retained and wall sconces installed (dining room) at same locations
- white mantel over fireplace in master bedroom determined to be a later addition, as no matching design details could be found anywhere in the house and it did not appear to fit in with the Arts and Crafts era aesthetic
- all trim removed, stripped, tagged (with a numbering system), and reinstalled with painstaking effort and attention to detail

* See attached 2 page list on technical upgrades, prepared for the BC Sustainable Energy Association tour (mid-project)

Mark Staples, finishing journeyman, David Coulson Design Ltd.

Comments made in response to a similar group of questions to those asked of David Coulson, with particular emphasis on the finishing products and procedures.

- door hardware was re-used throughout interior (bronze plating and oil finish by Victoria Plating); though some were moved to new locations, most – including the living room pocket doors – have their original hardware *in situ*
- electrical plugs well sealed from drafts – including a vapour barrier and spray foam insulation
- fully insulated rim joist between all floors (also with vapour barrier)
- exterior cedar siding replaced in sections; paint scraped by hand where it had bubbled (no chemicals used on exterior), repainted in heritage colours
- low VOC (volatile organic compound) paint used inside – minimal off gassing
- rotten soffit boards carefully repaired with matching fir pieces
- minimal coolants due to use of geothermal heat exchange
- kitchen dimensions same as before, though it would have been a single door to the back deck
- tie-in between original house and below-ground addition seamless … rear profile unchanged
- walkway and rear dormers only exterior changes visible from street level (not including garden layout and front gate)
- citrus-based paint strippers used on interior wood easy to work with and safe for crew members
- Farrow and Ball clay-based paints – likewise safe for employees and occupants

APPENDIX B: Page Notes from Standards and Guidelines

- Basic overall procedure should be as follows: a) identify c.d.e.s, b) determine treatment, c) review Standards, d) follow Guidelines
- Both **restoration** and **rehabilitation** apply to this project, according to outline
- If material used for replacement of features is identical to original (i.e. "in kind"), then the difference need only be noticeable upon close inspection (or in records). If not "in kind", then it must be distinguishable at a glance.
- Needed space for new rooms was incorporated into "a secondary, i.e. non-character defining interior space" – Guideline 3, Alterations / Additions for a New Use
- Standard # 8: Maintain character-defining elements on an ongoing basis. Repair c.d.e.s by reinforcing their materials […] Replace in kind any extensively deteriorated […]
- # 9: Make any intervention needed to preserve c.d.e.s physically and visually compatible with the historic place, and identifiable upon close inspection
- **Landscapes** – evaluation of both existing plantings and prevailing climate conditions
- **Buildings** – paint stripping should be done first by scraping / sanding, second by the application of heat, third by use of chemicals
- "Installing mechanical and service equipment on the roof such as […] solar collectors when required for the new use so that they are inconspicuous from the public right-of-way and do not damage or obscure character-defining elements, or undermine heritage value." (22)
- "Replacing in kind a window feature from the restoration period that is too deteriorated to repair using the same sash and pane configuration and other design details." (29)
- "Accomodating service functions such as bathrooms, mechanical equipment and office machines required by the building's new use in secondary spaces such as first floor service areas or on upper floors." (45) * works for all additions at 222 Vancouver St.
- "Reusing decorative material or features that have had to be removed […] and relocating such material or features to areas appropriate to their historic placement." * hardware
- "Adding a new floor if required for the new use in a manner that preserves character-defining interior spaces, features, and finishes." (46)
- "Removing or altering interior spaces, features or finishes […] dating from other periods." (47)
- "Adding a new floor when required for the new use if such an alteration does not damage or destroy the structural system or obscure, damage or destroy c.d. spaces, features or finishes." (50)
- "Installing a completely new mechanical system […] while insuring that it causes the least alteration possible to the building's floor plan and the exterior elevations." (54)

- **Health and Safety** – “Complying with health & safety requirements such as seismic standards […] in such a manner that c.d.e.s are conserved and heritage value is maintained.” (1)
- **Energy Efficiency Considerations** – “Weighing the total environmental cost of energy saving measures against the overall environmental costs of retaining the existing features.” (4)
- “Utilizing the inherent energy conserving features of a building by maintaining c.d. windows [and/or louvered blinds] in good operating condition for natural ventilation.” (5)
- “Maintaining c.d. porches […] so that they can retain heat or block the sun and provide natural ventilation.”
- **Environment** – “Complying with environmental objectives in such a manner that c.d.e.s are conserved and heritage value maintained.” (7)

APPENDIX C: Historical Notes

Directories

City Directory **1913** – Berridge, Wallace W. (acct Melrose Co.)

City Directory **1914** – Wallace W. Berridge (acct Melrose Co.)

City Directory **1915** – same, with Frank C. and William H. still living down the street

City Directory **1917** – Mrs. Adele F. Smith * no occupation

City Directory **1918** – A.B. MacKenzie (farmer)

City Directory **1920** – same as above

City Directory **1923** – Charles F. Earle (dist pass agt CNR) * also listed in **1925**, **1927**

City Directory **1930** – William C. Brown (salesman – Can. General Electric)

City Directory **1940** – Steph Amos (married to Doris; porter, HBC)

City Directory **1950** – Mrs. Rhea M. Dymond (rooms)

City Directory **1960** – Mrs. Laura I. Melander (widow; rooms)

City Directory **1970** – William T. Bendall (married to Laura I. Melander; rooms)

City Directory **1980** – Cynthia Arden (office mngr)

Publications

This Old House - "Introduction" (Victoria Heritage Foundation, 2004)

p. 3

- Fairfield's boom time! "A typical 60 ft by 120 ft residential lot in Fairfield, which sold for $400 in 1908, was selling for $5,000 in 1912."

- In the late 19th and turn of the 20th centuries, growth in canning, lumber, sealing, ship building, brokerage, and tourism all contributed to the economic expansion reflected in Fairfield's rapid development.

- By 1913, hundreds of houses had been built in the area

- The Panama Canal was completed in 1913, adding to land speculation frenzy

- The streetcar system was also connected to Fairfield at this time (along Cook St., between Fort and May) – enabling residents to access the downtown, as well as other outlying services (e.g. Jubilee Hospital)

- Vanouver's growth (CPR) and the start of WWI slowed this development

Exploring Victoria's Architecture (Martin Segger & Douglas Franklin, Sono Nis Press, 1996)

p. 10; 164

- California bungalows (based on mail order plans from California) were spec built throughout Fairfield and Oak Bay

p. 259

- Bungalow Construction Co. Ltd. was one such outfit that built many 5-6 room houses in Victoria

p. 129

- The "great land boom" is here identified as occurring between 1905 and 1912, bringing with it the popular look of the "Edwardian, middle-class neighbourhood"

p. 130

- "the land boom resulted in a competitive building industry that produced many spec built, bungalow-style residences in the neighbourhood"

p. 20/21

- popularity of Arts & Crafts design c.1905; inclusion of the customarily spacious hall area and the frequent use of Mission furniture, Japanese art wallpapers, and "the luxurious use of native wood wainscoting"

Wikipedia (http://en.wikipedia.org/wiki October 17, 2008)

- 1858 – discovery of gold on the BC mainland instantly converts Fort Victoria into a busy port, supply base, and outfitting centre for miners en route to the Fraser Valley
- 1866 – Victoria is politically united with the mainland
- 1871 – Victoria becomes the provincial capital (BC joins Confederation)
- 1886 – completion of the CPR terminus at Burrard Inlet literally terminates Victoria's status as the commercial hub of BC

** from that moment, Victoria begins to cultivate "an image of genteel civility"

* the real estate boom tapers off just before World War One

All time list of Canadian Transit Systems (David A. Wyatt, http://home.cc.umanitoba.ca/~wyatt/alltime/victoria-bc.html October 28, 2008)

7) 1880s – transit between Victoria and Esquimalt mainly by omnibus
8) 1890 – first streetcars ready; 4 cars and 9 k. of track; run by National Electric Tramway & Light Co. (ruined tragically by the Point Ellice Bridge accident, then replaced in 1897 with newly-incorporated BC Electric Railway)
9) 1914 – jitney service in Victoria, Oak Bay, and Esquimalt (about 100 in operation first year)
10) 1926 – advent of the motorbus

A Brief History of Transit in Victoria and the Lower Mainland (Scott Ingbritson, BC Transit Operator, posted on: www.transitworkers.novatone.net/PUBLIC/a_brief_history_of_transit.htm October 24, 2008)

- Feb.22, 1890 – Colonist reports: In the evening, the cars were brilliantly illuminated and filled with passengers, dashed [sic] through the streets in busy, metropolitan style, the admiration of all lovers of enterprise, convenience, and progress.
- June, 1913 – Interurban line opened in Saanich with 40k of track – closed due to underuse in 1924
- "BC Electric Railway began a period of expansion that lasted up to the beginning of WWI. The system grew so rapidly that BCER began manufacturing its own streetcars in New Westminster."
- Great Depression forces a massive drop in passenger numbers btwn 1932-34
- WWII good for business, as the rationing of fuel and tires encouraged many Vic citizens to use public transit
- 1948 – Victoria converts exclusively to motorbus public transit
- 2005 – BC Transit purchases 6 diesel/electric *Hybrid* buses from a Winnipeg-based company in order "to evaluate environmental and economic benefits of operating hybrid electric buses in the Kelowna and Victoria regions".

Wikipedia (October 23, 2008)

- *jitney* is a colloquial American English term for a five-cent piece, also used to refer to early public transport vehicles (something between a taxi cab and a bus)
- these jitneys were largely overtaken, and finally replaced, by the streetcar in both the US and Canada
- *omnibus* (orig. meaning "for all" in Latin) first engine-powered in 1895

A View of Victoria (http://web.uvic.ca/lancenrd/AViewofVictoria/streetcar/streetcar.php October 23, 2008)

- local publication Victoria's Streetcar Era by Henry Ewert (Sono Nis Press, 1992) is frequently quoted throughout this website and – for the most part – corroborates historical dates found elsewhere. A notable exception is the Point Ellis Bridge accident (alternately given as 1894 and 1896).

APPENDIX D: HOT 2000 Energy Assessment Report

Note that the following report is a combination of summary measures and homeowner reports.

HOT2000
Natural Resources CANADA
Version 10.31

File: Hot 2000.HSE
Application Type: EnerGuide for Houses

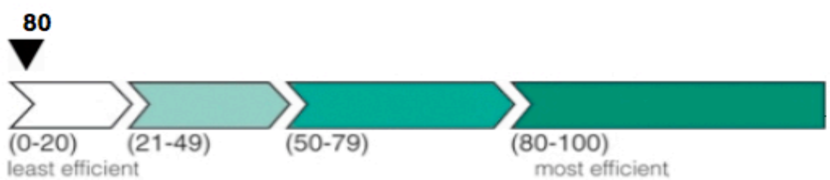
Builder Code: M00004

Data Entry by: Niels Anthonsen
Date of entry: 14/08/2008

Energy Efficiency Evaluation Report

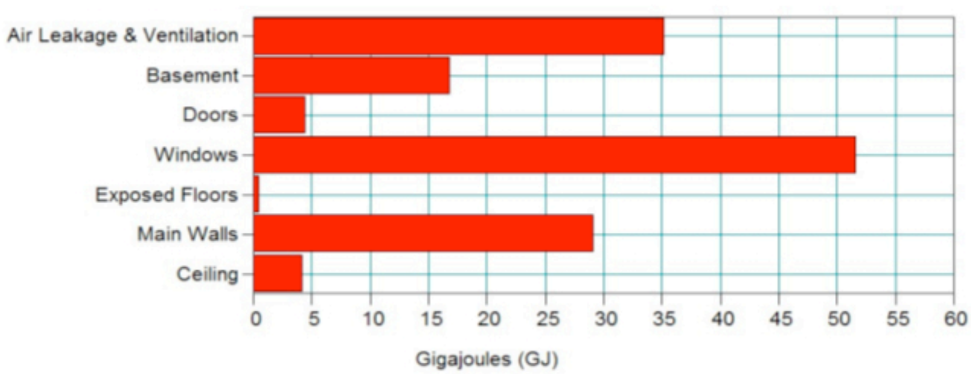
House file number: M00004

EnerGuide rating



- Your house currently rates 80.
- The average energy efficiency rating for a house of this age in Canada is 44.
- Your home rates in the top 5% of this group of houses.

Figure 1. Estimated Annual Heat Loss



GENERAL HOUSE CHARACTERISTICS

House type:	Single Detached		
Number of storeys:	Two storeys		
Plan shape:	Other, 9-10 corners		
Front orientation:	East		
Year House Built:	1910		
Wall colour:	Default	**Absorptivity:**	0.40
Roof colour:	Medium brown	**Absorptivity:**	0.84
Soil Condition:	Normal conductivity (dry sand, loam, clay)		
Water Table Level:	Normal (7-10m/23-33ft)		

House Thermal Mass Level: (A) Light, wood frame

Effective mass fraction 1.000

Occupants : 2 Adults for 50.0% of the time
2 Children for 50.0% of the time
0 Infants for 0.0% of the time

Sensible Internal Heat Gain From Occupants: 2.40 kWh/day

HOUSE TEMPERATURES

Heating Temperatures

Main Floor:	21.0 °C
Basement:	19.0 °C
TEMP. Rise from 21.0 °C:	2.8 °C
Cooling Temperature: Main Floor :	25.00 °C

Basement is- Heated: YES **Cooled:** NO **Separate T/S:** NO
Fraction of internal gains released in basement : 0.150

Indoor design temperatures for equipment sizing

Heating: 22.0 °C

Cooling: 24.0 °C

BUILDING PARAMETERS SUMMARY

ZONE 1 : Above Grade

Component	Area m² Gross	Area m² Net	Effective (RSI)	Heat Loss MJ	% Annual Heat Loss
Ceiling	102.73	102.73	7.10	4108.92	2.91
Main Walls	214.00	184.52	2.06	29099.06	20.58
Doors	1.86	1.58	0.37	1513.41	1.07
Exposed floors	7.64	7.64	5.50	451.41	0.32
South Windows	6.76	6.76	0.18	13254.39	9.37
East Windows	10.07	10.07	0.18	19450.85	13.75
North Windows	5.05	5.05	0.39	4632.06	3.28
West Windows	6.02	6.02	0.33	6390.63	4.52
		ZONE 1 Totals:		**78900.73**	**55.79**

INTER-ZONE Heat Transfer : Floors Above Basement

Area m² Gross	Area m² Net	Effective (RSI)	Heat Loss MJ
93.85	93.85	0.787	5871.96

ZONE 2 : Basement

Component	Area m² Gross	Area m² Net	Effective (RSI)	Heat Loss MJ	% Annual Heat Loss
Walls above grade	6.17	6.17	-	1139.10	0.81
Doors	3.72	3.25	0.37	2864.80	2.03
South windows	5.57	5.57	0.58	3156.31	2.23
East windows	3.05	3.05	0.54	1823.63	1.29
North windows	3.61	3.61	0.58	2031.09	1.44
West windows	0.46	0.46	0.19	802.80	0.57
Pony walls	64.30	48.35	2.26	8543.67	6.04
Below grade foundation	112.36	112.36	-	7056.32	4.99
		ZONE 2 Totals:		**27417.72**	**19.39**

Ventilation

	House Volume	Air Change	Heat Loss MJ	% Annual Heat Loss
	712.45 m^3	0.368 ACH	35107.988	24.82

AIR LEAKAGE AND VENTILATION

Building Envelope Surface Area: 507.20 m^2

Air Leakage Test Results at 50 Pa.(0.2 in H_2O) = 7.79 ACH
Equivalent Leakage Area @ 10 Pa = 2185.83 cm2

Terrain Description	Height	m
@ Weather Station : Open flat terrain, grass	Anemometer	10.0
@ Building site : Suburban, forest	Bldg. Eaves	8.2

Local Shielding:	**Walls:**	Heavy
	Flue :	Light

Leakage Fractions- **Ceiling:** 0.200 **Walls:** 0.600 **Floors:** 0.200

Normalized Leakage Area @ 10 Pa:	4.3095 cm^2/m^2
Estimated Airflow to cause a 5 Pa Pressure Difference:	348 L/s
Estimated Airflow to cause a 10 Pa Pressure Difference:	545 L/s

F326 VENTILATION REQUIREMENTS

Kitchen, Living Room, Dining Room	3 rooms @ 5.0 L/s: 15.0 L/s
Utility Room	1 rooms @ 5.0 L/s: 5.0 L/s
Bedroom	1 rooms @ 10.0 L/s: 10.0 L/s
Bedroom	1 rooms @ 5.0 L/s: 5.0 L/s
Bathroom	1 rooms @ 5.0 L/s: 5.0 L/s
Basement Rooms	: 10.0 L/s

SECONDARY FANS & OTHER EXHAUST APPLIANCES

	Control	Supply (L/s)	Exhaust (L/s)
Dryer	Continuous	-	1.20

Dryer is vented outdoors

AIR LEAKAGE AND VENTILATION SUMMARY

F326 Required continous ventilation:	50.000 L/s (0.25 ACH)
Gross Air Leakage and Ventilation Energy Load:	30153.834 MJ
Seasonal Heat Recovery Ventilator Efficiency:	0.000 %
Estimated Ventilation Electrical Load: Heating Hours:	0.000 MJ
Estimated Ventilation Electrical Load: Non-Heating Hours:	0.000 MJ
Net Air Leakage and Ventilation Load:	35107.988 MJ

SPACE HEATING SYSTEM

Primary Space Heating Fuel:	Natural Gas
Space Heating Equipment:	Water Source Heat Pump
Manufacturer:	Trane
Model:	GSWD 042 10D 22100T
Capacity at XT3 °C:	0.00 kW
COP at XT3 °C:	3.80
Crankcase Heater Power:	0.00 watts
Heat Pump Temperature Cut-Off:	Unrestricted

SPACE HEATING SYSTEM

Secondary Heating Fuel:	Electricity
Equipment:	Baseboard/Hydronic/Plenum(duct) htrs.
Manufacturer:	
Model:	
Calculated* Output Capacity:	14.00 kW

* Design Heat loss X 1.00 + 0.5 kW

Steady State Efficiency:	100.00 %
Fan Mode:	Auto
Low Speed Fan Power:	0 watts
High Speed Fan Power:	344 watts

AIR CONDITIONING SYSTEM

System Type:	Conventional A/C		
Manufacturer:			
Model:			
Capacity:	0 Watts	**Rated COP**	8.0
Sensible Heat Ratio:	1.00		
Indoor Fan Flow Rate:	0.00 L/s	**Fan Power (watts)**	0.00
Ventilator Flow Rate:	0.00 L/s	**Crankcase Heater Power (watts):**	0.00
Fraction of windows Openable	0.00		
Economizer control:	N/A	**Indoor Fan Operation:**	Continuous

Air Conditioner is integrated with the Heating System

DOMESTIC WATER HEATING SYSTEM

Primary Water Heating Fuel:	Solar
Water Heating Equipment:	Solar collector system
Manufactuer:	Apricus Inc.
Model:	APCP30
CSIA Solar Collector Rating:	69630.00 MJ/Year
Secondary Water Heating Fuel:	Solar
Water Heating Equipment:	B-Medium, Wood frame
Manufactuer:	Apricus Inc.
Model:	APCP30
CSIA Solar Collector Rating:	MJ/Year

ANNUAL SPACE HEATING SUMMARY

Design Heat Loss at -7.00 °C (19.46 Watts / m3):	13866.43 Watts
Gross Space Heat Loss:	141426.44 MJ
Gross Space Heating Load:	141426.45 MJ
Usable Internal Gains:	31500.95 MJ
Usable Internal Gains Fraction:	22.27 %
Usable Solar Gains:	30196.30 MJ
Usable Solar Gains Fraction:	21.35 %

Auxilary Energy Required:	79729.18 MJ
Space Heating System Load:	79729.17 MJ
Heat Pump and Furnace Annual COP:	3.35
Heat Pump Annual Energy Consumption:	22775.61 MJ
Furnace/Boiler Annual Energy Consumption:	0.00 MJ
Annual Space Heating Energy Consumption:	22775.61 MJ

ANNUAL SPACE COOLING SUMMARY

Design Cooling Load for July at 24.00 °C:	0.00 Watts
Design Sensible Heat Ratio:	0.00
Estimated Annual Space Cooling Energy:	0.00
Seasonal COP (May to October):	0.00

ANNUAL DOMESTIC WATER HEATING SUMMARY

Daily Hot Water Consumption:	225.00 Litres
Hot Water Temperature:	55.00 °C
Estimated Domestic Water Heating Load:	15104.57 MJ
Solar Domestic Water Heating System Contribution:	14680.90 MJ
Domestic Water Heating Energy Consumption:	4611.79 MJ
System Seasonal Efficiency:	Secondary 9.19

BASE LOADS SUMMARY

	kwh/day	**Annual kWh**
Interior Lighting	3.40	1241.00
Appliances	9.00	3285.00
Other	7.60	2774.00
Exterior Use	4.00	1460.00
HVAC Fans		
HRV/Exhaust	0.00	0.00
Space Heating	0.80	292.00
Space Cooling	0.00	0.00
Total Average Electrical Load	24.80	9052.00

FAN OPERATION SUMMARY (kWh)

Hours	HRV/Exhaust Fans	Space Heating	Space Cooling
Heating	0.00	292.00	0.00
Neither	0.00	0.00	0.00
Cooling	0.00	0.00	0.00
Total	0.00	292.00	0.00

ENERGUIDE FOR HOUSES ENERGY CONSUMPTION SUMMARY REPORT

Estimated Annual Space Heating Energy Consumption	= 43207.84 MJ	= 12002.18 kWh
Ventilator Electrical Consumption: Heating Hours	= 0.00 MJ	= 0.00 kWh
Estimated Annual DHW Heating Energy Consumption	= 4611.79 MJ	= 1281.05 kWh
ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION	= 47819.63 MJ	= 13283.23 kWh
ENERGUIDE RATING (0 to 100)	80	
EnerGuide Required Ventilation Capacity	0.00 L/s	

Estimated Greenhouse Gas Emissions 10.01 tonnes/year

MONTHLY ENERGY PROFILE

Month	Energy Load (MJ)	Internal Gains (MJ)	Solar Gains (MJ)	Aux. Energy (MJ)	HRV Eff. %
Jan	19224.726	2700.282	1721.781	14802.663	0.000
Feb	16179.386	2438.964	2180.841	11559.581	0.000
Mar	15801.110	2700.282	3187.257	9913.571	0.000
Apr	12398.155	2613.176	3443.565	6341.414	0.000
May	9170.388	2700.282	3355.633	3114.472	0.000
Jun	6252.276	2613.176	2724.217	914.884	0.000
Jul	4619.719	2537.949	2025.719	56.051	0.000
Aug	4807.477	2569.923	2148.707	88.847	0.000
Sep	6948.232	2613.176	3027.427	1307.629	0.000
Oct	11639.742	2700.282	2999.083	5940.377	0.000
Nov	15543.703	2613.176	1880.762	11049.764	0.000

Dec	18841.516	2700.282	1501.310	14639.924	0.000
Ann	141426.438	31500.949	30196.301	79729.180	0.000

FOUNDATION ENERGY PROFILE

			Heat Loss (MJ)		
Month	**Crawl Space**	**Slab**	**Basement**	**Walkout**	**Total**
Jan	0.000	0.000	2435.203	0.000	2435.203
Feb	0.000	0.000	1901.407	0.000	1901.407
Mar	0.000	0.000	1630.629	0.000	1630.629
Apr	0.000	0.000	1043.026	0.000	1043.026
May	0.000	0.000	512.203	0.000	512.203
Jun	0.000	0.000	150.394	0.000	150.394
Jul	0.000	0.000	9.217	0.000	9.217
Aug	0.000	0.000	14.581	0.000	14.581
Sep	0.000	0.000	214.986	0.000	214.986
Oct	0.000	0.000	977.069	0.000	977.069
Nov	0.000	0.000	1817.539	0.000	1817.539
Dec	0.000	0.000	2408.086	0.000	2408.086
Ann	0.000	0.000	13114.341	0.000	13114.340

FOUNDATION TEMPERATURES & VENTILATION PROFILE

	Temperature (Deg °C)			Air Change Rate		Heat Loss
Month	**Crawl Space**	**Basement**	**Walkout**	**Natural**	**Total**	**(MJ**
Jan	0.000	19.465	0.000	0.482	0.488	5329.754
Feb	0.000	19.527	0.000	0.466	0.472	4371.067
Mar	0.000	19.687	0.000	0.436	0.442	4089.520
Apr	0.000	19.913	0.000	0.389	0.395	3024.581
May	0.000	20.204	0.000	0.324	0.330	2016.324
Jun	0.000	20.592	0.000	0.269	0.275	1240.969
Jul	0.000	21.230	0.000	0.221	0.227	846.679
Aug	0.000	21.234	0.000	0.218	0.224	871.359
Sep	0.000	20.662	0.000	0.270	0.276	1369.230
Oct	0.000	20.099	0.000	0.360	0.366	2666.984
Nov	0.000	19.732	0.000	0.439	0.445	4059.514
Dec	0.000	19.531	0.000	0.480	0.486	5222.006
Ann	0.000	20.161	0.000	0.362	0.368	35107.988

The calculated heat losses and energy consumptions are only estimates, based upon the data entered and assumptions within the program. Actual energy consumption and heat losses will be influenced by construction practices, localized weather, equipment characteristics and the lifestyle of the occupants.

APPENDIX E: 1910 Plumbing Permit

CITY OF VICTORIA.

Application for a Permit to Construct House Sewers and Connections with the Public Sewers.

At the Building and premises located on the West side of Vancouver Street, between ~~Fairfield~~ Park Boulevard Street and Oliphant Street, being 40 feet from Vancouver Street, South Part on Lot, No. 1422. 1694 Block, No. 56.

..................Estate or Registered Plan, No. ....

Plan submitted, Numbered (.........) ....

Owner Mrs W. Berridge Address..................

Pipe layer J. Sullivan Address..................

Plumber Hayward & Dods Address 927 Fort St

Purpose of building Residence

How many Buildings One

Pursuant to the provision of Sewers By-Law of the City of Victoria, application is hereby made to the City Engineer of the said City for permission to construct sewers on the above mentioned premises in accordance with the accompanying plans and these ~~particulars, and to connect~~ the said sewers with the public sewer in.................. street. The undersigned hereby agreeing to cause the work to be done in accordance with the aforesaid By-Law, and the standard specification provided for in the said By-Law, the material to be furnished in accordance therewith, and such modifications as may be required by the City Engineer, and further, that all work herein contemplated will be executed in a workmanlike manner.

No modification of the plan and these particulars, or of the work described therein, will be made unless the same is previously allowed by the City Engineer, and all work pertaining to the proper plumbing and sewerage of the buildings and premises which is not covered by the plan and these particulars, but is found necessary during the progress of the work in order to carry into effect the true intent of the By-Law, and standard specification, shall be executed in accordance with the directions of the said City Engineer aforesaid.

NOTE—Earthernware Sewers are shown on the plan in red lines, and metal pipes in blue lines.

Mrs Berridge *Owner.*

Date 21st *day of* April *1910* ....*Agent for owner.*

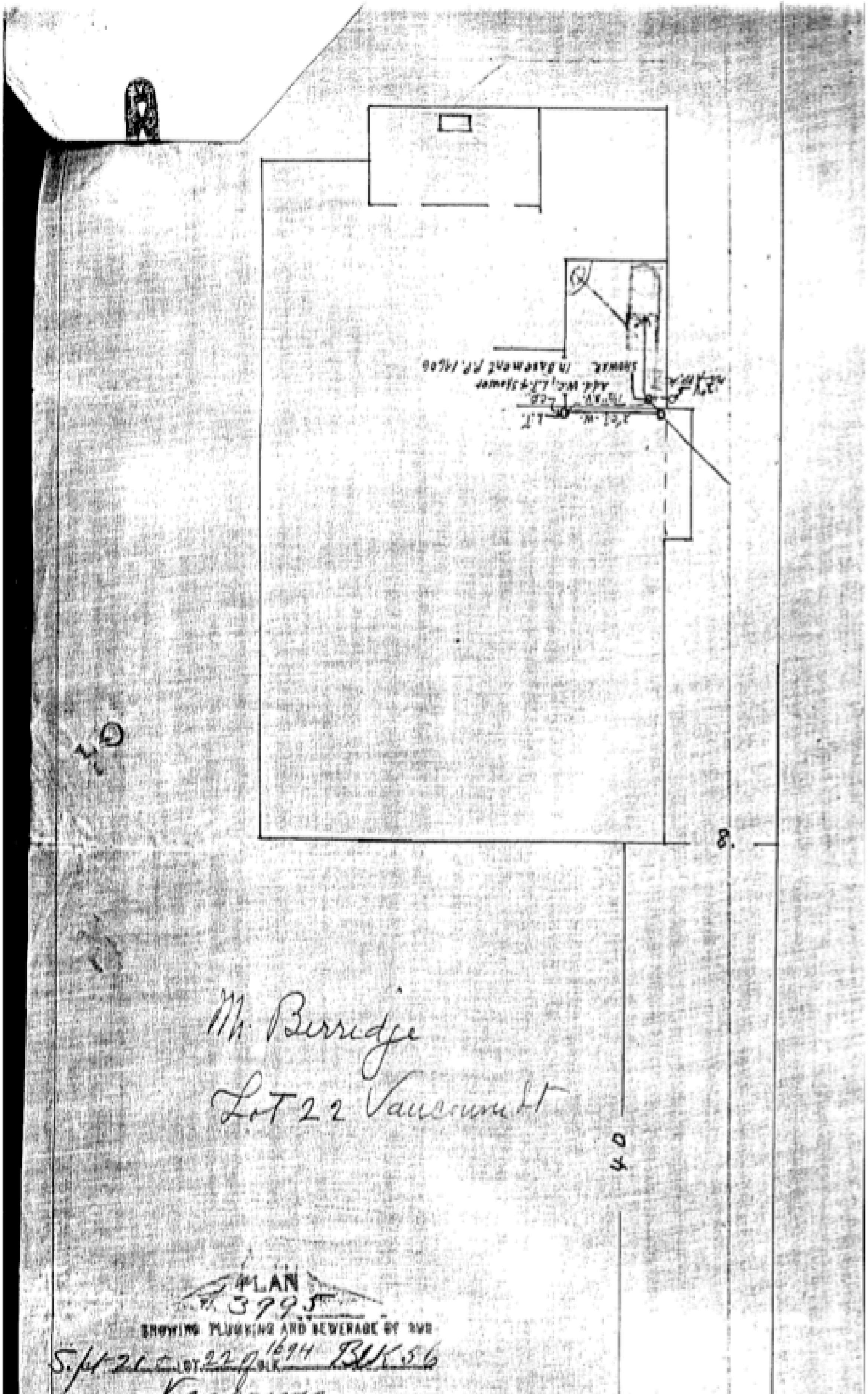
Report and Recommendation of Inspector

I report that I have examined the plans submitted with the foregoing application and find the same to be in compliance with the requirements of Sewers By-Law. I therefore recommend that a permit be granted for the construction of the work.

....

Inspector of Plumbing and Sewerage.

..................*day of*..................*190*......



Mr Burridge
Lot 22 Vancouver St
40
40
8
PLAN
A 3795
SHOWING PLUMBING AND SEWERAGE OF SUB
S. pt 21 LOT 22 BLK 1694 BLK 56

/C ✓

Plan No. 3995.

21st April 1910

APPLICATION

—TO—

Connect With Sewer

#222 Vancouver

~~Belcher~~ Vancouver Street

W. Berridge Owner

LOCATION VANCOUVER 222 OWNER NORRIS, ALBERT B. (1952) ~~A.G. [illegible] (1951)~~ P. PLAN NO. 3995

LOT S Pt. 21 N Pt. 22 BLOCK 56 MAP 24 ROLL NO. N-1902-3 2122-3 DATE 21.4.10 ~~3-10-51~~

PIPE LAYER S. INSP. △ INSP. FINAL S. I. & △

PLUMBER JOURNEYMAN CARD NO.

ROUGH INSP. FINISH INSP.

B.P. P. PERMIT NO. NEW RECORD

COVERING INSTALLATION OF RECORD OF EXISTING PROP:

STOREYS	W. C.'s	BATHS	SINKS	BASINS	L. TRAYS	URINALS	OTHER FIXTURES
BASEMENT							
FIRST FL.	See	welfare	file	re	plumbing	system	check 16/6/75 F.B.
SECOND FL.							
THIRD FL.							
ADD: ST.							
✓							
							MICROFILMED MAR 3 1959

POSITION OF HOUSE SEWER

W - Oliphant
& Park
Boulevard

HOUSE

ST.

DATA

ADDITIONS AND ALTERATIONS

DATE 26-3-52 B. P. No. 28,502 P. P. No. 14,696

PLUMBER ALEX RAWLINGS JOURNEYMAN CARD No. 114

add in basement 1 WC. 1 Shower 1 LT.

R.P.I. 27-3-52 F.B. F.P.I. 16-5-52 F.B.

Location: 222 VANCOUVER

Lot: Block: Section: Plan: Roll:

Date: Permit No: Value:

Owner or Agent: MRS. LAURA T. MELANDER

Address: 222 VANCOUVER

Architect: Contractor: Lic:

Zone District: Fire Limits:

Occupancy: No. of Rooms:

Converted to: 6 L.H.K. Date: 29. 8. 58 Case No: By Registration

Class Construction: Size Bldg: Height:

Size Lot: Setbacks: (side) (front) (back)

Joists: (Grnd) (2nd) (3rd) (Ceiling)

Foundation: Ext. Walls: Posts: Beams:

Floors: Rafters: Chimneys: Basement:

Roof: Stairs: Exits: Heating:

Plumbing: Wiring:

Other Structures:

Alterations and Repairs:	Date:	Permit:	Value:
Reside exterior walls, with Glatex Asbestos Shgles.	2.6.59	43548	$1,760.00
Install furnace - Southacks	19.11.62	11974	~~$~~
" "	21.11.62	51274	$687.00
Install tank only - Menzies	27.11.63	12945	-

Location: 223 Vancouver St Owner: Mrs Laura I Melander

Designated Occupancy: Light housekeeping rooms License:

Schedule of accomodation for owner's use and for rental purposes:-

Self-contained suite #	Floor (main, 2nd, etc.)	Three-piece bathroom	Sink	Number of rooms	Cooking Facilities Gas	Electric	Oil	Wood
					X			

Housekeeping unit #	Floor (main, 2nd, etc.)	Bathroom Shares	Bathroom Own	Sink Shares	Sink Own	Number of rooms	Cooking Facilities Gas	Electric	Oil	Wood
1	"	"	[illegible]		✓	1 [illegible]	X			
1	"	"		"		1	X			
1	"	"		"		1	X			
1	2nd	"		"		1	X			
1	2nd	"		"		1	X			
1	"	"		"		1	X			

Heating: Packaged Unit Furnace Room: Coal__ Wood__ Sawdust___ Oil X Gas___
Zero Clearance:___ Enc:__ Not Enc:___ Electric______
Fire Escapes: X Wood: X Metal:____ Stairway open: X Stairway closed: ________

Special Details: Gas Domestic heater Hot Water

Building Inspector.

In the matter of the Zoning Bylaw No. 4382 of The Corporation of the City of Victoria as Amended.
I Mrs. L. I. Melander.
of the City of Victoria, in the Province of British Columbia, DO SOLEMNLY DECLARE:
That the described premises were used for the purpose of providing the housekeeping accomodations (defined in Bylaw 4382 prior to July 24, 1958.) as noted on the reverse side of this registration, and the facts shown upon this form are true.
And I make this solemn declaration conscientiously believing it to be true.

Dated: 29 day of Aug 1958 Mrs L I Melander

This registration must not be construed to infer that this building necessarily conforms with the Fire Marshal Act.

APPENDIX F: Photographs

Figure 7 - Front view, from Vancouver Street (east)

Figure 8 - Back view (west); note solar panels on rooftop

Figure 9 - Fully restored 1910 staircase (from second floor)

Figure 10 - Original bronze-plated hardware on dining room pocket door

Figure 11 - Restored Arts and Crafts fireplace in main entrance

Figure 12 - Original dining room (full scale, unchanged from 1910) showing second main floor fireplace and a selection of interior wood details and custom Arts and Crafts furnishings

Figure 13 - HRV supply vents, located on the ceiling of the second floor master bedroom

Figure 14 - Geothermal well head (disguised by raised vegetable bed in south side garden)

Figure 15 - Detail of front garden (south-east corner)