100-Mile Home:
Deconstruction and Material Reuse as Source and Sink of Single-Family Home Building Materials

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Report prepared at the request of CityStudio and the City of Vancouver in partial fulfillment of UBC Geog 419: Research in Environmental Geography, for Dr. David Brownstein
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1.0 Executive Summary

The main objective of this report is to demonstrate the feasibility of a 100-mile home in Metro Vancouver and provide recommendations to support the practice of building deconstruction and material reuse. The City must champion the effort to increase materials reuse. Recommendations include:

- **Demonstration** in civic and institutional buildings;
- **Communication** of quantifiable benefits through community engagement;
- **Rewarding** practitioners of deconstruction and reuse with financial (tax) incentives.

A *demonstrate - communicate - reward* strategy that will popularise the idea of materials reuse and help integrate its practice within the region. This includes: civic demonstration of materials reuse in new community and institutional buildings; quantifying and communicating success and engaging this knowledge within the community; offering tax credits to those practicing materials reuse, and implementing extended producer fees on new materials in order to highlight the financial benefit of salvaged materials.

A comparison between construction and demolition generated wastes, and single-family home building materials stocked by local and regional materials reuse centers demonstrates that roughly three-quarters of material types can be sourced as salvaged goods. This implies the ability to divert up to three-quarters of waste volumes to be reused in new homes if there were an equally high demand for salvaged materials. The four materials reuse centers in Metro Vancouver sell approximately 3% of the residential construction and demolition generated waste, indicating the potential and need to popularise and expand this market.

In Metro Vancouver, construction and demolition of residential homes generates 241,000 tonnes of waste, annually. The three major components of this are wood waste (50%), mineral aggregates (concrete; 30%), and metals (5%). In accordance with Metro Vancouver’s goal of 80% waste diversion by 2020, retaining materials high within the 5Rs hierarchy (*Reuse and Recycle*) demonstrates the potential for construction and demolition wastes to be *salvaged and reused* as a resource pool for newly built single-family homes.
2.0 Introduction

2.1 Metro Vancouver’s Residential C&D Waste Situation

In Metro Vancouver, construction and demolition of residential homes generates 241,000 tonnes of waste, annually. The three major components of this are wood waste (50%), mineral aggregates (concrete; 30%), and metals (5%). In accordance with the region’s waste management goals, 80% diversion of construction and demolition wastes must be achieved by 2020 (Metro Vancouver, 2010). This is for both the short and long term benefit of the region, and represents an end goal that will facilitate a sustainable and equitable future. The goal of this research is to aid CityStudio in developing sustainability solutions that will help achieve the region’s Greenest City 2020 goals.

![Figure 1. Residential demolition-generated wastes in Metro Vancouver (Metro Vancouver, "Market Analysis", 2012).](image)

2.2 The 5Rs Hierarchy

This report focuses on the top components of the City of Vancouver’s internally recognised 5Rs hierarchy and how building deconstruction is the key to successful landfill diversion. The top most component within the 5Rs hierarchy is “Reduce.” This is the overriding principle, and may be satisfied by the next levels, “Reuse” and “Recycle” - the two components which will be the focus of this report. Maintaining materials at a high level within the 5Rs hierarchy implies retaining the most intrinsic value possible. That is to say, reducing the designation of materials as “waste” at the source implies continued use in its present form; reusing is re-
application of previously used building materials for a similar purpose; recycling, sometimes referred to as downcycling, is reprocessing of materials into lower quality products at the end of their useful life (BioRegional, 2009).

### 2.3 Building Deconstruction

Under the 5Rs hierarchy, waste materials can be considered a valuable resource through the act of building deconstruction, rather than an externality of construction and demolition. Deconstruction is, quite literally, reverse construction of a building - an environmentally and economically conscious alternative to demolition (Greer, 2004). Chini and Bruening (2003) outline the basic steps to building deconstruction, presented here in Figure 3. Waste reduction, then, can be achieved by building deconstruction and materials salvage; reuse can be achieved by resale of these materials for use in new homes. The practice of deconstruction and the market for salvaged materials have the potential to grow in the Metro Vancouver region.

This report will examine the benefits and drawbacks of building deconstruction and salvaged material reuse. I hope to demonstrate the comprehensive resource base that construction and demolition wastes may provide for use in single family homes, and examine the feasibility of a 100-mile home. Although this report is general in scope, I will conclude with recommendations that are relevant and applicable as local strategies of waste diversion.

### 3.0 Method

The primary resources for my report were academic literature and organisation reports. Using these sources, I was able to locate information on various aspects of building deconstruction and material reuse. The findings section of this report will be split into the three relevant spheres of sustainability: environmental; economic; and social. Barriers to deconstruction will then be discussed.

Another component of my research was evaluating which materials are commonly salvaged and sold for reuse. Using regional waste data and inventories of the wares offered by local and regional
salvaged materials stores, I estimated the percentage of salvaged materials applicable for use in new homes. Of the four salvaged material resale stores in Metro Vancouver, primary consideration is towards the Habitat for Humanity ReStore, as it is a successful model with outlets across Canada and the United States, and achieves the highest turnover of goods.

4.0 Benefits of Deconstruction

A review of current and relevant literature shows that building deconstruction is a viable alternative to demolition, offers environmental, social, and economic benefits, and can therefore be considered a sustainable practice. The following subsections outline aspects of deconstruction in the three aforementioned categories, followed by a summary of the difficulties and barriers associated with deconstruction.

4.1 Environmental

Building deconstruction with the intent of material reuse has many environmental benefits. The two most significant benefits are energy savings and landfill diversion. In other words, how materials are created - or in this case, sourced from deconstruction - and what will happen to materials once deconstructed. Most immediate to the time of deconstruction, energy savings are already countable. For instance, deconstruction uses mostly manual labour and simple tools, rather than the high-energy machines used for demolition (BioRegional, 2009). This aspect, however, produces high labour costs, a drawback which will be discussed in the Economics subsection, and recommended upon in a later part of this report. Another significant benefit of particular interest to local and regional municipalities is the potential for landfill diversion.

4.1.1 Embodied Energy Savings

The greatest benefits of deconstruction and subsequent materials reuse are energy savings and carbon emissions reductions (BioRegional, 2009; Essex and Whelan, 2010). The energies embodied in the production of a manufactured good are saved when material reuse is practiced. This is a highly variable measure, though easy enough to conceptualise. For example, when using salvaged materials: the heat energy required when cooking bricks may be entirely eliminated; the power required to harvest and mill lumber is saved; and environmental externalities associate with materials harvest and production are avoided.
The environmental impact of transportation is a major component of energy savings. Morel et al. (2001) find that the embodied energy in houses built with locally sourced stone masonry or rammed soil contributed to an average transportation impact of 560% less than factory-sourced concrete built homes. They demonstrated that as a material is sourced from a closer salvage site (in their study, from on-site) energy savings are greater. Therefore, it can be said that there is an inversely proportional relationship between the embodied transportation energy savings and the distance from material source. That is, the farther a material is transported, the more energy is embodied within a material, and thus the more energy is saved when a material is sourced as a salvaged product. Furthermore, the Canada Green Building Council offers Leadership in Energy and Environmental Design (LEED) credits for local production of building materials that are transported a maximum of 800 km by truck or 2400 km by rail (CaGBC, 2012). If the production source of salvaged materials is considered to be the deconstruction site, the LEED standards for local production are readily achievable.

4.1.2 Landfill Diversion

Landfill diversion represents the primary component of the 5Rs hierarchy - reduction of waste generation from the source. There is a huge potential for landfill diversion if building deconstruction is widely adopted across the Metro Vancouver region. In doing so, deconstruction will produce valuable goods out of what would otherwise be demolition-generated wastes. Significant reductions to landfill inputs is implicit in the long term sustainability of our region as it will relieve land pressures associated with locating new landfill area - a consideration of particular importance in the geographically constrained Metro Vancouver region.

As previously discussed, residential demolition accounts for 241,000 tonnes (18%) of the 1.3 million tonnes of waste generated annually in Metro Vancouver (Metro Vancouver, 2010). The four salvaged material retailers that currently exist in Metro Vancouver sell an estimated 2,100 to 12,700 tonnes of salvaged material each year - this represents an average of 3% of the regions residential construction and demolition generated wastes. The Habitat for Humanity ReStore, Metro Vancouver’s most prominent salvaged material retailer, advertises a diverse inventory of salvaged goods: lumber, drywall, windows, doors, trim, siding, flooring, plumbing and electrical fixtures, cabinets and furniture, and other items including simple objects such as nails and screws (Habitat for Humanity, 2012). When considering the above listed inventories of the salvaged material retailers in comparison to the three major residential demolition waste categories (wood, 50%; concrete, 30%; metals, 5%), there is a potential to divert up to and beyond three-quarters of material wastes by category type - whether by material reuse or downcycling. The City of Vancouver recently undertook two pilot projects to analyse
the potential for house deconstruction. Pilot I and Pilot II demonstrated the potential successes of deconstruction and were able to achieve a 93% diversion rate from the landfill (Metro Vancouver, “Pilot I and II”, 2012).

4.2 Economic

Economic analysis of building deconstruction is a complex consideration. An increasingly complex web emerges as costs, savings, and salvage revenues are considered. Guy and McLendon (2003) express the net cost of deconstruction in an easily understood equation: (Deconstruction + Disposal + Processing) – (Contract Price + Salvage Value) = Net Deconstruction Costs. On a basic level, this equation demonstrates that decreased spending on disposal and the revenue from salvaged materials has the potential to make a deconstruction project more cost-effective than demolition.

To begin with, the costs of deconstruction are initially much higher than demolition. On average, immediate deconstruction costs are found to be between upwards of 20% greater due to labour (Guy and McLendon, 2003). Naturally, as a work crew becomes more experienced in the practice of deconstruction, and if houses are properly assessed for their feasibility of deconstruction, efficiency will increase and costs will decrease. Immediate savings associated with deconstruction include an eliminated need for hauling and disposal fees. Finally, the resale value of salvaged goods is what makes deconstruction the better option. The net cost of deconstruction has been found to be from 10% to 50% less than demolition (Guy and McLendon, 2003; Greer, 2004). This is based on factors that influence the revenue of salvaged materials, such as volume, quality, and “wholesale” versus “retail” pricing schemes. Although deconstruction requires a greater upfront cost, it is an investment when considering the return from salvaged material sales.

<table>
<thead>
<tr>
<th>Costs</th>
<th>Additional Costs for Deconstruction as % of Total Demolition Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>+35%</td>
</tr>
<tr>
<td>Disposal</td>
<td>-22%</td>
</tr>
<tr>
<td>Hazardous</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>+8%</td>
</tr>
<tr>
<td>Total</td>
<td>+21%</td>
</tr>
<tr>
<td>Salvage</td>
<td>-61-31%</td>
</tr>
</tbody>
</table>

Another economic component of deconstruction is the potential employment and revenues associated with the refurbishing and redistribution network. Remanufacturing and refurbishing has the potential to increase the value of salvaged materials, and in doing so create a demand for skilled labour, thus enriching the overall market for salvaged goods (Essex and Whelan, 2010). For example, the Habitat for Humanity ReStores in
Metro Vancouver each employ two paid managers and a truck driver (Metro Vancouver, “Market Analysis”, 2012). As Guy and McLendon (2003) put it, “disposal is a one-time economic multiplier.” That is, the job-potential for demolition is limited to the act of sequestering wastes within a landfill. On the other hand, the economic multipliers associated with deconstruction, refurbishing, resale, and final reuse make material salvage a richer option. Furthermore, the demand for skilled labourers in the deconstruction industry implies potential for creation of education and training networks.

At the materials level, economic advantages are visible to the purchaser. The retail cost of salvaged materials ranges from 20% up to 90% less than new products (Habitat for Humanity, 2012; Metro Vancouver, 2012; Greer, 2004; Guy and McLendon, 2003; Falk, 2002). The variability in savings is based on factors such for-profit or non-profit pricing schemes, and whether a material is merely resold or refurbished. A particular advantage when buying salvaged timbers is the increased quality of wood. Falk (2002) explains that many houses set for deconstruction were often built from old-growth trees harvested before logging restrictions were put in place, and thus offer a desirable salvage material.

4.3 Social

Falk describes deconstruction and material salvage as occurring as far back as ancient Egypt, and common in the years before World War II (2002). However, the social benefits associated with deconstruction are abstract and largely unmeasured. In a recent study observing waste disposal habits, Wu et. al. (2013) found that people are roughly 30% more likely to make a “correct” or pro-environmental choice when in a sustainably designed building. This demonstrates the implications of those living in homes built using salvaged materials. Furthermore, there is potential to nurture life-skills and sustainable fundamentals in youth and hard to employ individuals such as demonstrated by groups including the California ReUse Institute, and Washington’s ReUse Consulting and the City of Vancouver’s recent deconstruction pilot projects (Metro Vancouver, “Market Analysis”, 2012; Metro Vancouver, “Pilot I and II”, 2012).

The Habitat for Humanity ReStore is a major distributor of salvaged materials in Metro Vancouver because of the associated brand name (Habitat for Humanity, 2012). This demonstrates the importance of a developed business network, and the effect of both community and regional engagement upon successful business networks. Essex and Whelan (2010) document the success of municipally-operated non-profit reuse centers in Belgium, which exist at a ratio of 1:60,000 residents
and support distribution through online material trade networks - an efficient and effective method of distribution.\(^1\)

### 4.4 Barriers to Deconstruction

The barriers to deconstruction are equally as variable as the benefits of deconstruction. Smith et. al. (2007) list the major challenges facing the deconstruction industry: education; markets; labour cost; environmental regulation; perceptions of low quality; storage requirement; and damage to wood. These demonstrate overarching socio-cultural, technical, and economic factors that are limiting popularisation of deconstruction practices.

The socio-cultural barriers to deconstruction may be considered the underriding problems from which others stem. Among the reasoning includes what some describe as forgotten lifestyles of “elegant frugality” (Lovins, as cited in McKibben, 2008, p. 568). One of the most influential factors, as mentioned above, is the perceived low quality of used goods. This is only sometimes a true case, as salvaged timber may either be of extremely high quality, or degraded due to nail removal, insect damage, and adhesives. Nonetheless, one inhibiting factor is the prevalent perception of “new” as synonymous with “better”, and the highly consumptive lifestyles of the post-war Western world that inhibit popular adoption of deconstruction and salvaged material reuse.

Of particular influence in our region is economic rationale. The notoriously high housing property value dwarfs the relatively low cost of materials to the point of economic disinterest. At the construction level, the low value of new building materials is not of significant influence upon contractors. Metro Vancouver’s “Market Analysis” (2012) documents the reluctance of a contractor to pay a carpenter $40/hr to salvage a $2 piece of lumber. The low cost of new materials fails to reflect environmental externalities, for example, and would benefit from a more complete pricing. Another factor disincentivising material deconstruction and reuse is the low cost of tipping fees. Guy and McLendon (2003) find that there is greater potential to encourage deconstruction by raising disposal fees, rather than by increasing salvage value. However, this is merely a topical solution that fails to address the underlying issue of regarding environmental degradation as mere externality.

\(^1\) Web exchanges including “BuilderScrap”, “Construction Resale”, “Earth Exchange”, and “Salvo” offer web-inventories, photos, and bidding functions similar to eBay (Essex and Whelan, 2010).
On a technical level, there is an absence of a grading standard for salvaged materials (Smith et al., 2007; Falk, 2002). This greatly limits the extent of materials reuse due to factors such as building standards. For example, a contracting company may face reputational and legal implications for sub-par material quality. Another physical drawback to deconstruction is damage and contamination of wood, including toxic paints, insulation, and adhesives - a general lack of what Falk (2002) describes as “design for deconstruction” (DfD). Furthermore, Metro Vancouver lacks infrastructure providing material drop-off and redistribution sites, and what is offered suffers from disaggregation of supply (Metro Vancouver, “Market Analysis”, 2012).

5.0 Recommendations

The path to successfully increasing deconstruction and material reuse in Metro Vancouver will involve the regional government championing the effort through a process of demonstrate-communicate-reward. This includes civic demonstration in new institutional building, and in the deconstruction of old buildings. For example, local buildings such as the Center for Interactive Research on Sustainability (CIRS) and the C.K. Choi building for the Institute of Asian Research - both on UBC Point Grey campus - demonstrate a future-thinking DfD model. A regionally coordinated deconstruction hub with online inventories will serve to aggregate salvaged material supplies and provide potential for small and large scale projects.

Quantification and communication of the positive effects of deconstruction is also key to success. This must be in understandable terms relatable to the individuals in order make a lasting impression. For example, the kilograms of CO2 savings for reused timber studwork in an averaged sized home may be expressed as equivalent to reducing automobile mileage by approximately half for one year. Communicating quantifiable success and engaging communities in meaningful experience has the potential to help overcome the misconceptions of low quality. Furthermore, by educating youth

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2 Use of salvaged timber studwork may save up to 900kg CO2; reducing personal car mileage by 25% saves 540kg CO2 per year (BioRegional, 2008).
and adults in the theory, process, and ongoing practice of deconstruction and material reuse, there is the potential to embed sustainability values within society.

Finally, financial benefits will further enhance the popularisation of deconstruction and material reuse. Tax credits may be awarded to practicing contractors, and individuals who opt towards salvaged material homes and LEED certification milestone achievements. A shift away from a symptoms-approach pricing to recognised intrinsic values of products will help rationalise the choice of salvaged materials. Furthermore, extended producer responsibility fees on new materials have the potential to draw attention to the more affordable option of salvaged goods.

6.0 Conclusions and Future Research

This research summarised the environmental, economic and social benefits of building deconstruction and subsequent material reuse. In doing so, an examination of the wares offered by local material reuse centers contrasted with the waste types generated by Metro Vancouver found that roughly 80% of residential building materials may be considered locally sourced through the use of salvaged materials. Future research on this topic would do well to develop the concept of a “100-mile home” and create an inventory of the type and source of material components found in an average single-family home. An ongoing assessment of material quality is also necessary as the age of the housing stock used for deconstruction shifts to more recent decades.
7.0 References


Metro Vancouver. (2012). (Chart and table illustration of material diversion, cost/revenue, and project comparison). Metro Vancouver Deconstruction Pilot I and Pilot II Projects. Received from City of Vancouver correspondent Rachel Moskovich.

