Industrial Symbiosis in the HRM:
Upcycling Waste in Sustainable Construction

PUT WASTE IN ITS PLACE | RRFB NOVA SCOTIA

Davin St. Pierre
Dalhousie University Masters of Resource and Environmental Management Report
Resource Recovery Fund Board of Nova Scotia Student Research Grant Project

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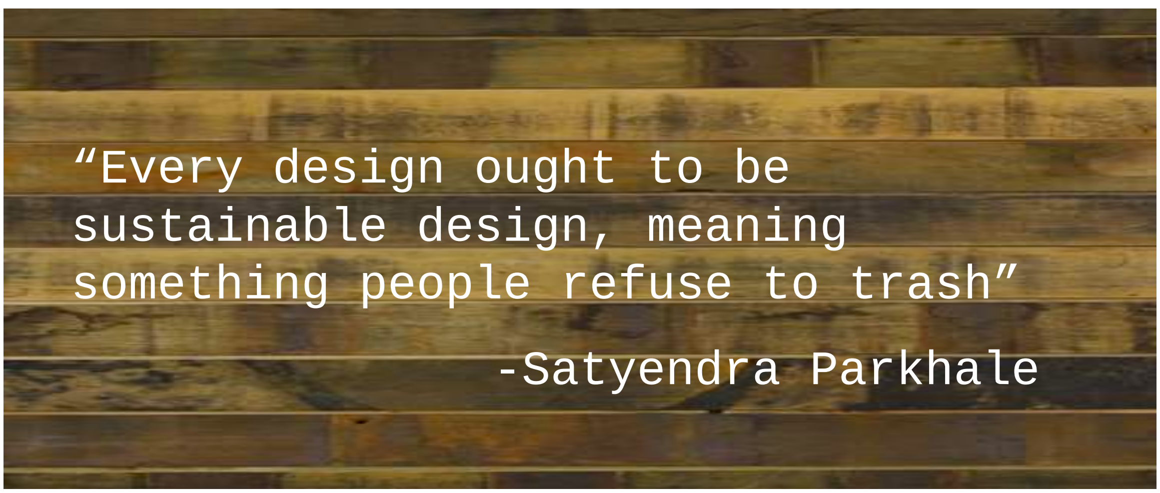

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Purpose

Through consultation sessions with regional industry, regulatory, and government stakeholders, this report aims to explore the barriers that exist with the development of a recycled and reused building material market in the Halifax Regional Municipality (HRM). This report also seeks to address how issues behind modern material and energy consumption trends in the life cycle of residential homes can be resolved by reusing and recycling waste materials deemed "*troublesome*" by the Resource Recovery Fund Board of Nova Scotia. It is hoped that the policy, regulation, and program recommendations within this report be used as potential options for the municipality and province to address these issues. For the purpose of this report, focus was placed on construction and demolition materials (with further focus on waste wood), and tire derived aggregate.

Where possible, this project also sought to create actual symbiotic relationships between waste processors and building professionals who were receptive to incorporating waste materials in their building designs.

Methods

This report was developed using a variety of multidisciplinary resources. Scholarly references (including case studies, journal articles, and literature reviews) were combined with industry reports and government documentation to provide a background of lifecycle research in home construction and worrisome trends behind material and energy consumption in residential homes. Newer work had precedence in sourcing, however, older material was still included where applicable. To provide a relevant regional context for the issues being raised, the latest Nova Scotia waste audit was often referenced to highlight the volumes of waste managed within the province.

The stakeholder consultation framework was developed using academic and industry report references, as well as the United States Environmental Protection Agency report titled *Developing Markets for Recyclable Materials: Policy and Program Options* (1993). Based on this framework, industry, regulatory, and governmental stakeholders who could potentially deal with the supply, processing, or consumption of useful waste building materials were invited to partake in consultation sessions. Although topics of conversation within the consultation sessions varied depending on the stakeholder, sample questions can be found in Appendix B of this report.

Based on the research findings and through the stakeholder consultations, key recommendations were formed which drew upon best practice examples from other national and international jurisdictions, expert opinion, and academic research references. Throughout the report, information drawn from the stakeholder consultations have been referenced as "Consultation Notes, 2013".

Guiding Concepts

The interdisciplinary nature of this project was scoped by a handful of concepts that ultimately shaped the way in which the project was conducted. The guiding concepts of the project allowed for a "system" view of the issues being analyzed, which was necessary because of the multitude of industries, regulations, and strategies that effect the decision making and design processes of the built environment.

Guiding Concepts
The Hierarchy of Waste Management
Integrated Recycled Material Markets
Industrial Ecology and Symbiosis
Eco-Efficiency

The Hierarchy of Waste Management and Waste Classification

The hierarchy of waste management is a ranking of the most environmentally sound strategies for municipal solid waste (EPA, 2013). The ranking itself is an order of options for non-hazardous wastes from most desirable options to least desirable options. In essence, the hierarchy of waste options is an effort to "*protect the environment and conserve resources for future generations through a systems approach*" that seeks to reduce material use and their associated environmental impacts over their entire life cycles (EPA, 2013). The life cycle of materials usually refers to the extraction, processing, use, and end-of-life options of a specific material.

From most preferred/desirable to least preferred/desirable waste management options, the hierarchy ranks source reduction and reuse as the highest, followed by recycling/composting, energy recovery, and lastly treatment and disposal (EPA, 2013). The outright prevention of a specific product's use is the ideal option for managing its waste; however, products we rely on as a society must be managed much more closely so that they continue to serve their societal function, but can be disposed of or reused in a sustainable manner (St. Pierre, 2013). The outright disposal of waste is considered the weakest, most harmful, and usually most environmentally costly option within the hierarchy. Reintroducing waste materials into consumption loops is a worthwhile venture to save on the variety of costs involved with disposal of material.

Section 189.1 of the International Green Construction Code provides some of the most universally understood definitions of terms used to classify waste materials for green building programs in North America, they are:

Recovered Material – *Material that would have otherwise been disposed of as waste or used for energy recovery (e.g. incinerated for power generation), but has instead been collected and recovered as a material input, in lieu of new primary material, for a recycling or manufacturing process.*
Reuse – *Includes donation of materials to charitable organizations, salvage of existing materials onsite, and packaging materials returned to the manufacturer, shipper, or other source that will reuse the packaging in future shipments.*
Recycled Material – *Material that has been reprocessed from recovered (reclaimed) material by means of a manufacturing process and made into a final product or into a component for incorporation into a product.*
Recycled Content – *The proportion, by mass, of recycled material in a product or packaging. Only pre-consumer and post-consumer materials shall be considered as recycled.*

(IGCC, 2011)

Referring to the IGCC waste terms and the hierarchy of waste management was useful throughout this report as they served as guidance for the upcycling potential of waste materials assessed in this project.

Integrated Recycled Material Markets

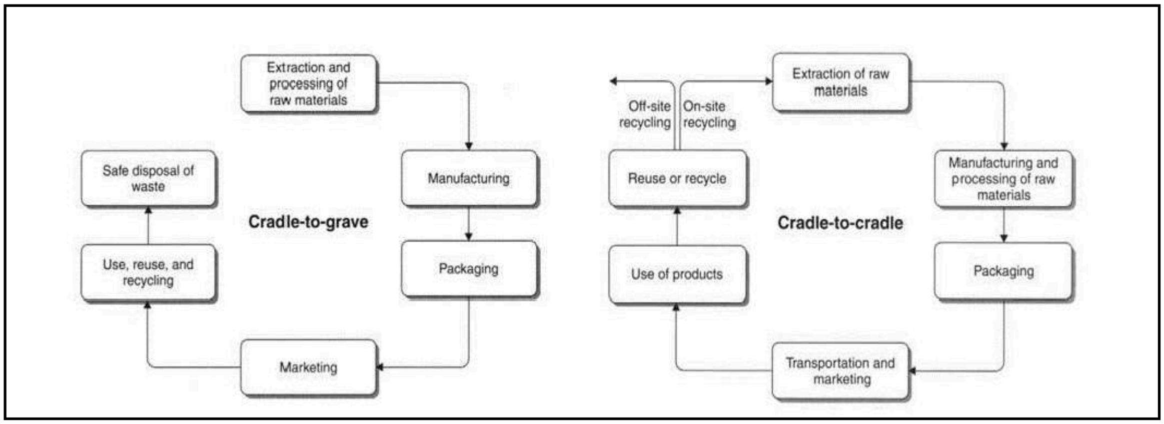
In theory, repurposing materials should be a straightforward venture; however, creating a market for recycled materials is vital for stimulating the repurposing of recyclable materials in the public and industry (USEPA, 2012). Providing stimulus and development of a recycled material market requires research in to specific wastes produced, diversion methods, uses for those materials, and providing a market for those materials to then be repurposed. The shift behind producing higher value purposes for recycled materials instead of simply being recycled for the sake of recycling can be referred to as upcycling (Gray et. al., 2013). By creating markets for specific waste materials, value-added uses for wastes occur, and financial benefits become increasingly viable for waste materials through all levels of their life cycle.

Successful recycling, effective recovery of waste materials, and widespread reuse, depends on an integrated system and relies primarily on three factors:

• An adequate, reliable, and clean supply of reused or recyclable materials
• Demand by processors (involved in cleaning, grinding, pulping, or re-engineering waste materials) or retailers of secondary material to absorb supply the supply of reused or recycled materials
• Consumer demand for reused material or recycled material products sufficient to absorb the supply

(USEPA, 1993)

Sustainable waste management and recycled material markets, at their core, are based around closing the production, consumption, and disposal loops of products and materials in the most sustainable ways possible. By capitalizing on the later stages of a products lifecycle, we can transform a materials life from a *cradle-to-grave* system (based on disposal), towards a *cradle-to-cradle* system (based on recirculating waste materials into consumption loops) (El-Haggar, 2007).



(El-Haggar, 2007)

Creating a closed-loop system with waste materials aims to capitalize on initial energy inputs, consumed resources, emissions, as well as reduces the harmful and costly effects of waste disposal, in repurposing. Statistics show that paper recycling can reduce air pollutants by 75% and water pollution by 67%; using scrap steel and iron can result in an 86% reduction in air pollution and a 76% reduction in water pollution; recycling aluminum saves 95% of the energy used to produce it from virgin products, not to mention the intangible savings behind avoiding virgin resource extraction/use and deleterious disposal methods (NEO, 2013).

The concept of developing waste material markets inherently becomes integrated by nature because of the variety of industries vested in a specific materials lifecycle. Waste generators, collectors, processors, re-manufacturers, investors, and end-users are considered the primary potential barriers to a recycling market's development (USEPA, 1993). Managing through providing incentives or creating disincentives for each of sector involved in the creation of a recycling market is necessary to develop sustainable and continuous markets for waste materials. The establishment of a recycling market in any jurisdiction involves the application of a variety of tools depending on the unique features and services that any one jurisdiction may have at its disposal.

Industrial Ecology and Symbiosis

Industrial Ecology (IE) looks from a systematic and integrated perspective on the industrial economy and its relation with the biosphere, emphasizes the biophysical substratum of human activities (material and energy flows, etc.), and considers technological dynamics to gauge potential success of a viable industrial ecosystem (Erkman, 1997). While the term “industrial ecology” is inherently contradictory, the field of industrial ecology has opened the door for industrial systems to be analyzed much like natural systems to develop relationships between entities of industry in mutually beneficial relationships.

These industry relationships sometimes manifest in energy savings/sharing, material savings/sharing/exchange, cost savings/sharing/exchange, etc. depending on the variety of factors involved in a system being analyzed. An eco-industrial park, as defined by Dr. Ray Coté, a leading academic and IE professional, is a network of firms that cooperate with each other to improve economic and environmental performance by minimizing the use of energy and raw materials through the planned materials and energy exchanges (Côté, 1998).

Nova Scotia, and the Halifax Regional Municipality in particular, is not unfamiliar with the concept of an eco-industrial park. The Burnside Industrial Park is one of Canada’s greatest examples of industrial symbiosis at work, which includes over 1,500 businesses that have improved environmental and economic efficiency with a variety of synergistic relationships involving the reuse of polystyrene packaging, recycling of corrugated cardboard, toner cartridge refurbishing, silver recovery program with print companies, a “paint swap” program with paint consuming businesses, and potential chemical exchanges among chemical companies in the park (Peck, 2001).

Industrial Symbiosis (IS), which plays an integral role in the successful function of industrial ecology, is described a relationship between two or more firms where the unwanted by-products of one firm are used as a resource by another (Graedel & Allenby, 2010). At its core, industrial symbiosis mimics biological systems in that it focuses on product and resource recycling/reuse to create closed loop systems which produce less waste and requires fewer natural resources and energy to function (Davidson, 2011).

There are typically five different categories, or scales, of industrial symbiosis. These scales range from the sale or donation of waste material from one source to another, to the widespread exchange of material and resources across broad spatial boundaries (Chertow, 1998; Graedel & Allenby, 2010).

Five Categories of Industrial Symbiosis

Category 1	Occurs through waste exchanges where recovered materials are sold or donated to another firm. These exchanges are unplanned and so may not be considered a true example of IS
Category 2	Involves the exchange of materials within a single facility, firm or organization, but between different processes
Category 3	Co-located firms in a defined industrial area exchange materials and resources
Category 4	Firms in relative proximity to each other engage in the exchange of materials and resources
Category 5	Firms organized across a broad spatial region exchange materials and resources

(Chertow, 1998)

This project is an exercise in the potential industrial symbiosis that could exist in the HRM between waste producers, waste managers, construction/design professionals, as well as recycled material retailers. Where possible, real relationships were fostered to develop the earliest stages of potential symbiosis in this industry.

Eco-Efficiency

Eco-efficiency as a concept is more of a management philosophy than a management tool and can be used to measure environmental and economic performance (Hellweg et al., 2005). In the field of waste management, eco-efficient philosophy meets a unique application because of the dynamic nature of waste streams, the variable value of the waste materials depending on the jurisdiction of focus, and the political/environmental frameworks that waste materials are governed by. The World Business Council for Sustainable Development defines eco-efficiency as:

• Reducing the consumption of resources: energy, materials, water land, through recyclability and closed-loop material systems
• Reducing impact on nature: minimize emission, water contamination, sustainable use of renewable resources
• Increasing product or service value: concentrating service and products that meet customer needs through functionality, flexibility, and modularity requiring fewer materials and fewer resources.

(WBCSD, 2000)

In short, eco-efficiency is concerned with creating more value with less impact (WBCSD, 2000). Eco-efficiency as a philosophy works in harmony within other frameworks to find a common ground, maintaining value of a product while also considering its environmental impact. Eco-efficiency can be understood mathematically as:

$$\textbf{Eco-efficiency} = \frac{\textbf{value added}}{\textbf{environmental impact}}$$

(Bohne et al., 2008)

Introduction

Humans are dependant on the built environment for survival. One of our most basic human needs, shelter, is a human necessity to life on Earth, and is a science humans have attempted to perfect since the beginning of man. As shelter is a necessity to human life, residential construction has also become one of the most impactful drivers of the modern economy. Housing-related spending in 2005 accounted for nearly one-fifth of total economic activity in Canada, and contributed nearly $260 billion to the Canadian economy (CMHC, 2006). In Nova Scotia, recent trends show that the province is home to the largest number of single-family residence builds in the Atlantic provinces (CMHC, 2006). Nova Scotians spend between 22 and 23 percent of their salary on average for shelter, and construction directly employs roughly 30,000 people within the province, not to mention the 300,000 or more jobs tied to material manufacturing, transportation of materials, or servicing of the built environment (CMHC, 2006; Statistics Canada, 2013). It is an economic and human reality that modern society is tied to the success and efficiency of the built environment.

In relation to the natural environment, however, construction is hardly symbiotic. Two major issues exist with residential housing: energy intensity and waste. The energy intensity of our homes, being the sum of energy consumed in the pre-use phase, the use phase, and end of use phase of a homes lifecycle, is analyzed through embodied energy and operational energy. Traditionally, embodied energy (energy required to manufacture, install, and dispose of a home) represented roughly 25% or less of a homes total energy intensity, the rest consumed in its operational phase (Coldham & Hartman, 2006). In Nova Scotia where residential and industrial energy consumption is roughly two thirds of total provincial energy use, and 76% of the provinces energy comes from fossil fuels, the environmental impact of energy-intensive sectors such as these is magnified (Efficiency NS, 2012). Operational efficiency has been the focus of modern home design, and has made significant gains since the 1950's. However, as homes have become more efficient in operation, embodied energy has been steadily growing due to the use of more energy-intensive material to achieve these efficiency goals. Embodied energy is now being seen as a problematic obstacle in home design.

Massive amounts of natural resources are consumed in construction. It is estimated that construction activities alone consume 60 percent of yearly raw material extraction in the United States (USEPA, 2008). The growing worldwide demand for new construction materials is putting so much pressure on natural resources that the Worldwatch Institute estimates that if current consumption rates persist, by the year 2030 the world will be severely depleted of our most vital building materials (Gorgolewski, 2010). On the tail end of a homes lifecycle, waste from the construction, renovation, or demolition of homes (referred to as C&D waste) contributes 11 million tonnes of solid waste to Canadian landfills each year (RCO, 2006). Typically, 90% of this C&D waste is generated from residential demolition and renovation (RCO, 2006). In Nova Scotia, C&D waste represents 25%-30% of the provincial total waste stream and is a pressing concern among regional officials and professionals alike for the growing quantity of space C&D waste consumes in landfills, the lost capitalization of initial energy inputs in the extraction, transportation, and manufacturing of materials, and the overarching environmental effects of the traditional management practices of these types of waste (Government of Nova Scotia, 2011).

Although lowering embodied energy in homes and C&D waste management are two separate problematic issues, they are symbiotic in that they have mutually beneficial solutions. It has been well documented that the key behind lowering the embodied energy of homes and decreasing the amount of useful material that enters landfills exists in reusing and recycling waste materials in home construction (Milne & Reardon, 2010, CORRIM, 2009; Coehlo & de Brito, 2011; Coldham & Hartman, 2006, USEPA, 2008; RCO, 2006; Naturally Wood, 2013).

One of the key challenges in capitalizing on the reuse/recycling of waste materials is to develop closed-loop recycling/reuse material markets (USEPA, 1993). To develop this type of market, knowledge of the barriers that exist with either the supply of clean and quality waste materials, processor/retailer demand of waste materials, or consumer demand of reused/recycled materials in the jurisdiction of focus, is vitally important (USEPA, 1993). To investigate the potential of reused/recycled material use in the residential construction industry of Nova Scotia, professionals that have potential to be involved to any of the three components of a recycled market were selected to partake in consultation sessions. As the Halifax Regional Municipality (HRM) is the larges waste-producing region in the province, professionals in the HRM were specifically targeted.

Consultation sessions revolved around the discussion of waste material potential in residential construction, current construction practices, current knowledge, and issues/concerns on the subject of waste material use in construction. Resulting from these consultation sessions, input and common issues/concerns were summarized to form industry opinions on the barriers that exist around the development of a recycled building material market in the region. Following a brief snapshot of home lifecycle understanding, current waste management strategies and regulations in Nova Scotia and the HRM, current recycled/reused building material market in the HRM, and a summary of industry findings, key recommendations were formed and discussed that aim to address specific barriers to the development of a closed-loop recycled building material market in the region. Where possible, this project sought to create actual symbiotic relationships between waste processors and building professionals who were receptive to incorporating waste materials in their building designs. These examples of industrial symbiosis in action only graze the surface of the potential that exists in the HRM and Nova Scotia.

Material Focus

Because of the wide variety of sources in Nova Scotia that produce waste, and the even wider variety of wastes those sources produce, material focus was needed to effectively address issues around the incorporation of specific waste materials in sustainable residential construction practices. The RRFB of Nova Scotia, who are the primary research body of the province with regards to recycled material research, have a large scope of materials highlighted as being troublesome and requiring innovative solutions. These materials include C&D waste, textiles, paper products, organic materials, hazardous materials, and plastics (RRFB, 2013).

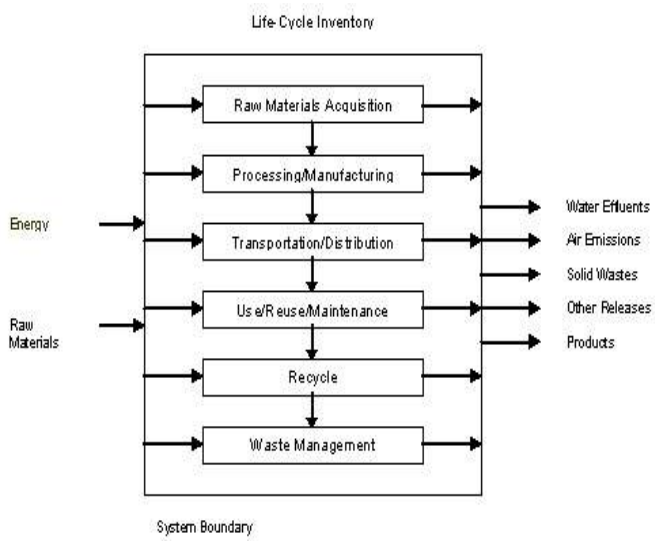
The materials of focus for this project were chosen based on a handful of different criteria, which include:

- waste materials deemed most problematic by the RRFB and constitute a large part of a waste stream
- materials not yet widely explored for repurposing in the region
- waste materials that are readily available
- waste materials that have proven recycling/repurposing strategies in construction practices in other national/international jurisdictions
- waste materials that offer differing examples of how the province reacts to existing waste management frameworks (bans, diversion practices, recycling/reuse options, etc.)

Based on the criteria listed above, the project focused on exploring the potential application of waste materials in residential construction practices mostly concentrating on: C&D waste (specifically waste wood) and waste tires. Most professional consultations were around these materials, however, materials such as waste glass and waste textiles were discussed and will be materials of mention in the report for their application in certain sustainable construction capacities.

Understanding the Life Cycle of Homes: A Case for Repurposing and Recycling

As defined by the International Organization for Standardization, a life cycle assessment (LCA) is a systematic set of procedures for compiling and examining the inputs and outputs of materials, energy, and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle (ISO, 2006). The majority of LCA's are used in research and development of products (inputs and designs), manufacturing, policy development, construction, and for sales and educational purposes (Cooper, Fava, 2006). When single products or services are considered, LCA's are significantly easier to quantify because they are based mostly on a fixed set of variables, and are considered through the five basic stages of a life cycle inventory: raw material acquisition; processing and manufacturing; transportation and distribution; use, reuse, and maintenance; recycling and waste management (IIRF, 2013).



(IFRF, 2013)

The LCA approach to assessing homes is similar, but is particularly challenging because of the multitude of materials that are used in home construction, the impacts those materials can have, the manner in which the home was built, the transportation costs at the homes various stages, and much more. In some cases, LCA's have even taken on a vastly more comprehensive approach that can be described as a full cost assessment (FCA). An FCA is a far reaching evaluation of a material or product that takes into consideration not only the direct and indirect financial and environmental costs of what is being evaluated, but the external and sometimes abstract costs borne by society (IISD, 2013). Examples of components in an FCA could be relating societal effects derived from global warming potential, resource consumption, air/water pollution, solid waste, off-gassing materials, and the use of carcinogenic substances in products and their associated effects. Whether through an LCA or FCA, homes must be understood in a comprehensive manner because of the vast impacts that our residential built environment has on our society.

Homes are generally analyzed based on three phases of a home's life cycle: pre-use, use, and end of life (Blanchard & Reppe, 1998). Because a common denominator is needed to quantify the impact of the house(s) being examined, primary energy use is often the most tangible and common quantifiable unit. Typically, these three phases encompass the following in a home LCA:

Pre-Use Phase	- energy consumed in manufacturing and transportation of all building materials used - energy consumed in construction of the house
Use Phase	- energy consumed in all activities related to the use of the home over an assumed life (heating, cooling, lighting and use of appliances) - energy consumed to manufacture all materials required to maintain the physical building and for home improvement projects
End of Life	- energy consumption estimated for eventual demolishing of the home (actual dismantling and transportation of waste to recycling operations or landfills) - energy consumption of recycling waste materials

(Blanchard & Reppe, 1998)

Through these phases, energy is analyzed as embodied energy, recurring embodied energy, or operational energy (Naturally Wood, 2013). In the pre-use phase, calculations are performed by creating an inventory of materials into home-system classifications. These classifications are normally represented as walls, roof/ceilings, floors, doors/windows, foundation, appliances/electrical, sanitary/HVAC, and cabinets (Balcomb, 1997). Using blueprints of a home, a volume of the required materials and their associated embodied energies are established based on the scope of the LCA. Ideally, academic or manufacturer-led LCA's have been conducted on the materials being used so that precise data can be included for accurate estimates of embodied energy. The following tables represent how this type of data is presented based on mega joules (MJ) per kilogram (kg) of a material, as well as generic meter squared (m^2) calculations for larger components of homes like flooring, structural assemblies, and roofing.

Material	**EE (MJ/kg)**
Kiln dried sawn softwood	3.4
Kiln dried sawn hardwood	2.0
Air dried sawn hardwood	0.5
Hardboard	24.2
Particleboard	8.0
Medium Density Fiberboard	11.3
Plywood	10.4
Glue-laminated timber/lumber	11.0
Plastics – general	90
PVC	80.0
Synthetic rubber	110.0
Acrylic paint	61.5
Stabilized earth	0.7
Imported dimension granite	13.9
Local dimension granite	5.9
Gypsum plaster	2.9
Plasterboard	4.4

Cement	5.6
Insitu Concrete	1.9
Precast steam-cured concrete	2.0
Clay bricks	2.5
Concrete blocks	1.5
Glass	12.7
Aluminum	170
Copper	100
Galvanized steel	38

Assembly	**EE (MJ/M^2)**
Floors	
Elevated timber floor	293
110mm concrete slab on ground	645
200mm precast concrete T	644

beam/infill	
Roofs	
Timber frame, concrete tile,	251
plasterboard ceiling	
Timber frame, terracotta tile, plasterboard ceiling	271

(Milne & Reardon, 2010)

Depending on the scope of the LCA, embodied energy in the pre-use phase can encompass gross energy requirement (GER), which is a measure of the true embodied energy of a material (Milne & Reardon, 2010). In some cases the GER can include the energy used to transport the materials and workers to the building site, the materials for the construction of the building shell or all materials used to complete the building, the upstream energy input in making the materials, or the embodied energy of urban infrastructure (roads, drains, water and energy supply), however, often times this is impractical to measure (Milne & Reardon, 2010). Instead, it is commonplace for embodied energy to be considered as process energy requirement (PER), which is a measure of the energy directly related to the manufacturing of a material and typically makes up 50-80% of a GER (Milne & Reardon, 2010). Although using a PER as an embodied energy analysis is simpler to quantify, and is common practice, it is nearly impossible to establish even a true PER for construction materials because of the extreme variability that exists with the lifespan of materials and types of energy fuel used on site and in manufacturing.

As the LCA process of homes modernized, a subcategory of embodied energy developed that included end of life phase considerations, like cost of recycling and home decommissioning strategies, but also the energy required to maintain, upgrade, or replace materials in the home during its use phase (Naturally Wood, 2013). This sub-category of embodied energy is called recurring embodied energy, and is largely dependent on the quality, function, installation, and performance of materials throughout a homes lifecycle. Manufacturer estimations and prior LCA's on materials are used as data input in modeling software to establish what materials will have to be replaced, how often, and their associated embodied energy within a home. Quality of product, quality of installation/home, amount of use, and maintenance are all variables that must be considered in this calculation referred to as differential durability (Cole & Kernan, 1996). Although many home structures, assemblies, and components have a life expectancy of 100 years or more, other components like roofing systems, sealants, and appliances can have a life expectancy as low as 3 years, largely depending on their quality (ATD, 2009; Palmeri, 2011). For any components to last their expected life, maintenance of their less durable sub-components is vital. It has been revealed that consumer preoccupation with lower initial construction costs derived from low-quality material use has dramatic effects on embodied energy in the lifecycle of structures. In an LCA study conducted on buildings with lower-cost/quality materials, at year 25, 50, and 100, massive increases in embodied energy were observed (Cole & Kernan, 1996).

Year	% Increase in Embodied Energy
25	57
50	144
100	325

(Cole & Kernan, 1996)

It should be noted that the accumulation of recurring embodied energy over a buildings lifetime is almost entirely attributed to replacing envelope, finishings, and service components; therefore, careful selection of high-quality and low-embodied energy material is most vital where differential durability calculations are being considered, especially with these three components (Cole & Kernan, 1996; Palmeri, 2011).

Operational energy is defined as the energy required in a building to heat, cool, ventilate, light, water, and power itself on an ongoing basis (Naturally Wood, 2013). Modeling software is specifically vital to the use-phase evaluation of a home. Energy-10 is an example of an energy-use modeling software package for small buildings and residential homes. Energy-10 is used to determine a homes energy consumption during its lifecycle using energy related parameters (e.g., building envelope, heat conductivity, electricity consumption of appliances, ventilation requirements), as well as average temperature, wind speed and humidity data in the region that is being analyzed (Balcomb, 1997).

Numerous examples exist of studies that establish the energy intensity of homes typically over a 20, 25, 50, 70, or more year period (Blanchard & Reppe, 1998; Mumma, 1995; Milne & Reardon, 2010; CWC, 2013). Home energy intensity using the three phases of a home LCA in its most basic form could be understood mathematically as:

$$\mathbf{EE + REE + ((OE)\ (LS)) = EI}$$

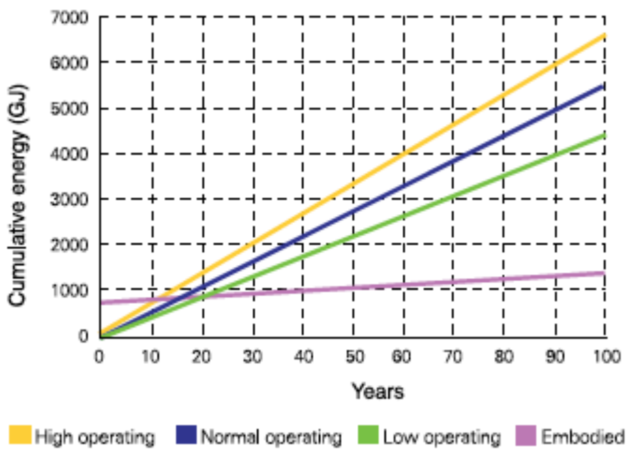
EE: Embodied Energy
REE: Recurring Embodied Energy
OE: Operational Energy (per year)
LS: Lifespan of Home (years)
EI: Energy Intensity

Early home LCA’s tended to report very similar results, where embodied energy consumed around 25% of a building’s total energy over its estimated life span (Coldham & Hartman, 2013; Palmeri, 2011). It should be noted that this percentage is largely dependant on the construction type of a home and its size. In a study done on identical size homes built with different materials, total embodied energy ranged drastically. Homes in this study were built to achieve similar operational efficiency to reflect true embodied energy values of equally performing homes. Wood-based building materials have consistently been rated as having substantially lower embodied energy (Mumma, 1995).

		House Type	
	Maximum Impact	**Most Common**	**Least Impact**
Floor	Concrete	Concrete	Timber
Exterior Wall	Brick	Concrete Block	Weatherboard
Roof	Corrugated galvanized steel	Corrugated galvanized steel	Concrete tile
Framing	Steel	Timber	Timber
Windows	Aluminum	Wood	Wood
Embodied Energy (GJ)	520	372	215

(Mumma, 1995)

Even though embodied energies were high in early homes, LCA trends saw a massive consumption of energy in the use-phase, and focus was put on creating more operationally efficient homes (Coldham & Hartman, 2013). The graph below represents average embodied energy trends and operational trends for high-operating (low efficiency) and low-operating (high efficiency) homes in Australia.



(Milne & Reardon, 2010)

Although this graph highlights the range in years where operational energy becomes equal with embodied energy (10-20 years of use on average in this case), it only represents an average embodied energy in homes, and not the increase in embodied energy that occurs with high-efficiency homes. In some ways, classic graphs such as these have successfully mislead consumers to think that embodied energy is the same for all building materials, and does not fluctuate drastically throughout a homes lifecycle.

From the late 1970's to the mid 1980's, the average home in the United States consumed around 10% less energy per single detached family household compared to homes in the 1950's (EIA, 2009). From homes built before 1950 to 2005, energy consumption per square foot of residential homes decreased by roughly 40% (USDE, 2012). This trend was similar in Canada, where residential and commercial buildings alike now consume 50-60% less energy in their use-phase from the mid 1900's to the early 2000's (CWC, 2013). This trend is due to government and industry focus on efficiency in homes. In Nova Scotia, for example, there are more than six government rebate/incentive energy efficiency programs directly geared towards existing home improvements, or new home building, with use-phase energy conservation as the primary goal (Atlantic Green Building, 2013). Efficiency Nova Scotia's Home Energy Assessment Service saved an average of 6,961 kWh per household for its 5,600 participants (Efficiency Nova Scotia, 2012).

However, as buildings become more efficient in operation, they consume more high – performance materials that are typically more energy intensive to manufacture (Coldham & Hartman, 2013). Mathematical analysis points to the reality that as home efficiency increases, embodied energy constitutes a growing percentage of total energy intensity because of the increase in efficiency and material. It has been recorded on several occasions where homes are so operationally efficient that a building may see more than half of its total lifetime energy requirement committed to embodied energy (Coldham & Hartman, 2013). In a recent study evaluating embodied energy ratios in two building energy certification programs in Belgium and Australia, the highest operational efficiency homes could require as much as 25 years of occupancy to break even on the embodied energy of the materials they were built with (Stéphan & Crawford, 2013). This reality is problematic for a variety of reasons. Firstly, although energy consumption in homes built between 2000 and 2005 consumed 40% less energy per square foot than homes built before 1950, the increased embodied energy and size of average single-family houses has offset most total efficiency improvements (USDE, 2012). For example, the average size of homes in North America from 1950 to 2008 increased from 950 sq. ft. to 2,500 sq. ft., which is not reflective of increased number of residents in homes, as the sq. ft. per person increased from 258.7 to 961.5 (Palmeri, 2011). This trend could be seen in Nova Scotia, where yearly total energy consumption per single-family household has been rising while the energy consumption per m^3 of homes has been relatively stagnant for many years (Statistics Canada, 2011).

Secondly, the median age of most homes does not reflect predicted average lifespan of residential homes (70+ years). In the HRM, 65% of homes or more were built in the 1970's or later (Government of Nova Scotia, 2013b). In Toronto for example, the average age of residential homes is 40, and in the United States, 36 (Mumma, 1995; USDHUD, 2010). In a residential home lifecycle study done in Oregon, it was found that the embodied energy of the identical homes at 20 years is 35% or more, and only lowers to 25% at 70 years (Palmeri, 2011). Some studies have shown this number can even be as high as 45% at the same 20-year mark (Architecture 2030, 2012). It can be assumed that the quality and durability of housing is not as high as is expected, which further increases the percentage of embodied energy in homes because of decreased lifespans.

In general, although efficiency technology has vastly increased, marginal decreases in use-phase energy costs are being documented because consumers in general are building bigger and lower quality homes that have more embodied energy (Coldham & Hartman, 2013). It can be concluded that since modern homes are being built to meet high-efficiency standards, the increase in embodied energy of materials are not being considered.

Along with energy, environmental effects of home construction are also significant. In a study assessing the environmental impacts of three 2,400 square foot homes, the wood, steel, and concrete designs were found to have vastly differing effects on the environment.

Total Energy Use	- Concrete home consumed 2.2 times as much energy as wood - Steel home consumed 1.5 times as much energy as wood
Global Warming Potential (GWP)	- Steel home produced 1.22 times more GHG - Concrete home produced 1.5 times more GHG
Air Toxicity	- Steel home produced 1.7 times the toxicity of wood on the index - Concrete home produced 2.15 times the toxicity on the index
Water Toxicity	- Steel home had 3.47 times higher effect on water toxicity - Concrete home had 2.15 times higher effect on water toxicity
Weighted Resource Use	- Steel home weighed was 1.15 time more - Concrete home weighed 1.93 times more
Solid Waste:	- Steel home produced slightly lower than wood - Concrete home produced 1.57 times more than steel

* Wooden home was considered to be the baseline as 1 (CWC, 2013)

It is clear from an energy and environmental standpoint that the most important factors in reducing the impact of a home's energy intensity is to design homes to be durable, efficient, with low embodied energy materials. The solution to address these three criteria does not exist with more extraction, but increased capitalization on materials already produced: waste. It has been well documented that the key behind lowering the embodied energy of homes and decreasing the amount of useful material that enters landfills exists in reusing and recycling waste materials in home construction (Milne & Reardon, 2010, CORRIM, 2009; Coehlo & de Brito; Coldham & Hartman, 2006, USEPA, 2008; RCO, 2006; Naturally Wood, 2013).

If materials are properly managed at the end of a buildings lifecycle, they have the potential to be either repurposed or re-manufactured in to perfectly usable building materials instead of entering landfills and degrading into harmful and troublesome waste. Where C&D waste accounts for 25%-30% of the total waste produced in Nova Scotia, there exists immense potential in lowering the embodied energy of homes in the province using waste building materials (Government of Nova Scotia, 2011). Although entire societal, environmental, and economic benefits are somewhat difficult to quantify, studies over the past 20-30 years have made more than a claim for the sweeping benefits material repurposing and recycling can have. On average, it is estimated that the reusing building materials saves about 95% of the embodied energy that would otherwise be wasted (Milne & Reardon, 2010; Murma, 1995). Environmental benefits of recycling or reusing building materials is also dramatic, reducing climate change impact by 77%, acidification potential by 57%, and summer smog impact by 81% (Blanchard & Reppe, 1998).

Typically, 75% or more of homes are made of concrete, steel, wood, and gypsum board, and therefore makes up the same percentage of its waste (RCO, 2006). In a study conducted by the Recycling Council of Ontario, the recycling and reuse of material from

15 decommissioned homes saved 1,073,563 kg of carbon dioxide emissions by diverting over 200,000 tonnes of waste from landfills through the avoidance of using new materials, reusing existing structures or materials, and recycling residues (RCO, 2006). Economically, the reuse and recycling of these materials saved more than $2.5 million in the new projects where the waste materials were diverted (RCO, 2006). Although the vast majority of these savings were from recycling and reusing energy-intensive materials like steel and concrete, wood reuse and recycling has significant potential in all-around savings as well.

It is estimated that the average 2,000 square foot home has 6,000 board feet of reusable lumber when decommissioned properly, which is the equivalent to 33 mature trees, or the yearly production of ten acres of planted pine (Shami, 2006). Although wood has a very low embodied energy compared to steel or concrete (1,380 MJ/m^3 compared to 251,200 MJ/m^3 and 3,180 MJ/m^3), in a study done assessing the extraction impact of raw building materials, timber harvesting was seen to have substantially more effects on the extent of area impacted, impact duration, significance of the area impacted, and ranked highest in total impact (CWC, 1997; Athena, 1994). It is estimated that if the 30 million tonnes of wood-related construction and demolition debris that enters landfills in the USA were diverted towards reuse; 5 million tonnes of methane gas emissions from anaerobic decomposition would be avoided (Munroe & Hatamiya, 2006). Considering 90% of homes are wood-framed, and wood has a low embodied energy, is a high performing and versatile building material, and is proven to sequester large amounts of carbon when protected from degradation, capitalizing on existing waste stocks through recycling and reuse has exponential advantages even for wood (PMI, 2013; Bowyer et. al., 2010).

Energy, environmental, and economic savings in home construction are not limited strictly to reused and recycled building materials. Waste materials from other waste streams also have significant potential in home construction. Insulation from recycled cellulose has 87% less embodied energy per kg than fiberglass insulation, and the r-value of sprayed-in cellulose insulation is 10% higher than that of fiberglass insulation (Blanchard & Reppe, 1998). Using 50% post-industrial vinyl and 50% recycled post-industrial wood for roofing material can lower the embodied energy of a roof system by 98% (Blanchard & Reppe, 1998). Crushed waste glass, although only saving 20% of its embodied energy when recycled for its primary purpose, has shown massive potential in being entirely reused as crushed glass in septic bed systems, completely replacing traditional aggregates in this application (Milne & Reardon, 2010; SNC Lavalin, 2006). Crushed waste glass in concrete mixes has also been proven to replace 20% or more of traditional aggregates in concrete mixes (Solterre Design, 2013). Tire derived aggregate (TDA), a product produced from waste tires, has emerged as an extremely useful building material in its application as exterior foundation insulation and drainage medium. TDA in numerous examples has greatly outperformed traditional materials in these applications and has diverted a troublesome waste from landfills towards a cost effective and useful alternative (CIWM Buffalo, 2012).

Although the benefits of using recycled and reused material in construction are widely known, the framework to support this type industry is, for the most part, severely under-developed. Because residential housing is a necessity of life, as is the preservation of our natural environment, it only seems logical to capitalize on useful and quality materials that would otherwise enter landfills and be replaced by raw virgin materials.

Unfortunately, where best practice examples do exist, the widespread adaptation of their successes has not occurred. The challenges that exist with creating a recycled material market are in ensuring the careful collection of a clean and quality supply of materials, the processing ability of recycled materials, and market drivers that are in place to incentivize a closed-loop system to consume waste products (USEPA, 1993). In order to adopt these types of frameworks there needs to be policy, regulatory, and industry implementation of specific strategies based on the exact barriers found in the jurisdiction of focus. To comprehend and to address these barriers, knowledge must be obtained from any and all stakeholders who may be vested in the potential development of a successful recycled building material market.

Background

Waste Policy Objectives of Nova Scotia and the HRM

The framework of waste policy in Nova Scotia has given birth to a variety of diversion and recycling objectives established by government officials and stakeholders alike (Refer to Appendix A, Figure 2). Nova Scotia was the first province in Canada to adopt the national goal of 50% waste diversion from municipal solid waste disposal by 2000 (Wagner & Arnold, 2008). The *Environment Act* of Nova Scotia (1995), which set the goals of 50% waste diversion from landfill sites, quickly led the Province to adopt the Solid Waste Resource Management Regulations and develop a Solid Waste Resource Management Strategy (Wagner & Arnold, 2008). Within the Solid Waste Resource Management Regulations, various recycling systems are employed, as well as the creation of the Resource Recovery Fund Board of Nova Scotia (RRFB).

The RRFB's Mission Statement is "*To work with Nova Scotians to improve our environment, economy and quality of life by reducing, reusing, recycling and recovering resources.*" (RRFB, 2011). As a not-for-profit organization, they undertake 5 distinct dimensions to waste management within the province. Their mandates are to:

- fund municipal waste diversion programs across the province;
- operate a deposit and refund system for beverage containers;
- develop and implement voluntary industry stewardship agreements;
- develop education and awareness programs; and
- promote the development of value-added manufacturing.

(Nova Scotia, 2013)

As an official waste management strategy and active body in the RRFB had been developed in Nova Scotia to meet the goals of the *Environment Act* (1995), sustainable waste management development in the province had a framework in which it could function. Of the many policy developments regarding waste management within the province, the *Environmental Goals and Sustainable Prosperity Act* (2007) scopes specific environmental goals that the province aims to achieve, all by 2020. The eight themes within the *Act* (2007) charged with targets for 2020 are ecosystem protection, air emissions, renewable energy, water quality, sustainable purchasing, solid waste, and energy-efficient buildings (Government of Nova Scotia, 2007). Based on the *Environmental goals and Sustainable Prosperity Act 2007: Progress Report 2012,* the ultimate goal of achieving solid-waste disposal rate no greater than 300 kilograms per person per year by the year 2015 was still a "Goal in Progress" (Government of Nova Scotia, 2012). In 2011, Nova Scotia reported a disposal rate of 401 kg/person, and in September of that year released *Our Path Forward: Building on the success of Nova*

Scotia's Solid Waste Resource Management Strategy (Government of Nova Scotia, 2012).

The main components of the original Solid Waste Resource Management Strategy were continued and focused in the Provincial Solid Waste Strategy: *Our Path Forward 2011*. This latest strategy was developed as a renewed solid waste strategy plan and has been implemented to ultimately achieve the goal of no more than 300 kg per person, per year, by 2015 (Government of Nova Scotia, 2011). The Strategy Renewal Advisory Committee for the development of *Our Path Forward* compiled input from various stakeholders in the province from municipalities, government departments, businesses, industry, and non-government organizations for the development of six distinct goals. The six goals resulting from these consultations are:

Goal 1: Increase participation in waste prevention and diversion
Goal 2: Improve compliance and education programs
Goal 3: Increase waste diversion
Goal 4: Increase cost-effectiveness of diversion programs
Goal 5: Increase producer responsibility for end-of-life management of products and materials
Goal 6: Increase diversion of construction and demolition waste*

*While all six goals of *Our Path Forward* resonate with the intention of this project, specific interest is given to increasing waste diversion, increased participation in waste prevention and diversion, and increase diversion of construction and demolition waste.

(Government of Nova Scotia, 2011)

Although *Our Path Forward 2011* is an amended provincial strategy, the municipal adoption of its goals is not necessarily uniform. Municipal waste management, as stated in the Municipal Government Act (MGA, 1998, ss. 49, 81, 325-326), allows for municipalities to form their own policies and by-laws for objectives towards diversion targets. The Halifax Regional Municipality (HRM) for example, set progressive minimum targets for the recycling or diversion of recyclable construction and demolition debris starting in 2001 at 50%, 2002-2005 at 60%, and 75% subsequent years (HRM, 2001). The existence of such a by-law is supported by by-law S-602, requiring all C&D waste generated within the region to be processed within HRM's municipal boundaries at certified facilities (Davidson, 2011). The HRM has strong municipal by-laws for the diversion of such materials to leverage the development of recycling initiatives within the municipality, and to gain credits through the RRFB's diversion program. For these reasons, the HRM is a useful jurisdiction to explore the potential of waste repurposing because of its ambitious targets.

Waste Streams in Nova Scotia

Waste in any jurisdiction is produced in a variety of streams and from a variety of sources. Waste varies in its source, but also its composition, volume, and management strategy. Typically waste composition is classified in to two sectors when audits are concerned: Institutional, Commercial, and Industrial (ICI), and Residential. The two together form what is often considered as municipal solid waste (MSW). The table below represents typical waste category source classifications, and types of waste created.

Source	Facilities, activities, or locations where waste was created	Types of Solid Waste
Residential	- Single-family and multifamily dwellings; low, medium, and high-density apartments - Can be included in ICI sector	- Food wastes, paper, cardboard, plastics, textiles, yard wastes, wood, ashes, street leaves, special wastes (including bulky items, consumer electronics, white goods, universal waste) and household hazardous waste
Commercial	- Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops	- Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes, hazardous wastes
Institutional	- Schools, universities, hospitals, prisons, governmental centers	- Same as commercial, plus biomedical
Industrial (non-process wastes)	- Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition	- Same as commercial
Municipal Solid Waste	- All of the preceding	- All of the preceding
Construction and Demolition	- New construction sites, road repair, renovation sites, razing of buildings, broken pavement	- Wood, steel, concrete, asphalt paving, asphalt roofing, gypsum board, rocks and soils.
Industrial	- Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition	- Same as commercial, plus industrial process wastes, scrap materials
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food, agricultural waste, hazardous waste

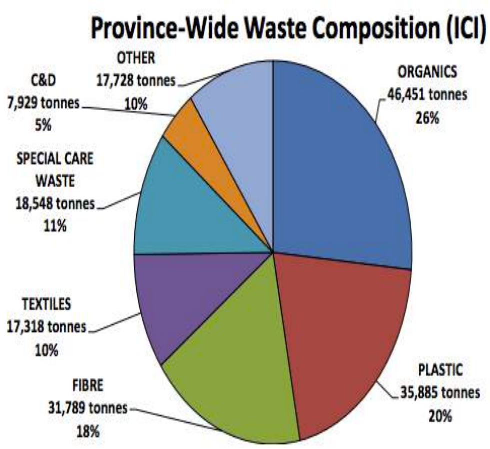
(Davidson, 2011)

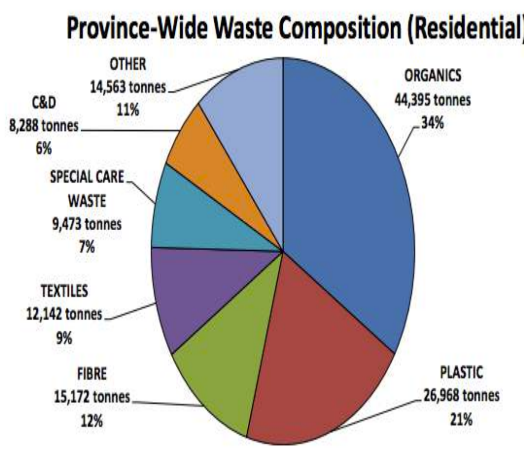
Different waste items within this table are dealt with in different ways in Nova Scotia and in the HRM. Some items have developed recycling potential, while others must be shipped out of province or disposed of in landfill. Materials banned from disposal in Nova Scotian landfills are:

- Desktop, laptop, and notebook computers, including CPUs, Keyboards, mice, cables and other components
- Computer monitors
- Computer printers, including printers that have scanning or fax capabilities or both
- Televisions
- Redeemed beverage containers
- Corrugated cardboard
- Newsprint
- Used tires
- Automotive lead-acid batteries
- Leaf and yard waste
- Post-consumer paint products
- Ethylene glycol (automotive antifreeze)
- Steel/tin food containers
- Glass food containers
- #2 HDPE non-hazardous containers (ice cream containers, plastic jugs, detergent bottles, etc.)
- Low density polyethylene bags and packaging
- Compostable organic material (food waste, yard waste, soiled and non-recyclable paper)

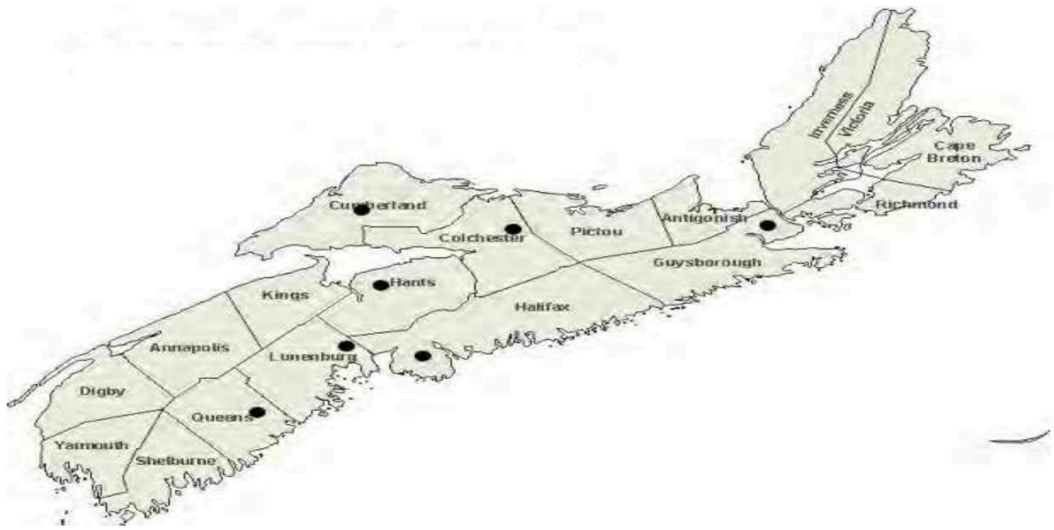
(NSE, 2013)

In April of 2012, an audit of provincial waste production reported 175,648 tonnes of waste produced in the ICI sector, and 130,997 tonnes of waste produced in the residential sector (RRFB, 2012a). Nova Scotia's waste composition per sector is as follows:





(RRFB, 2013)

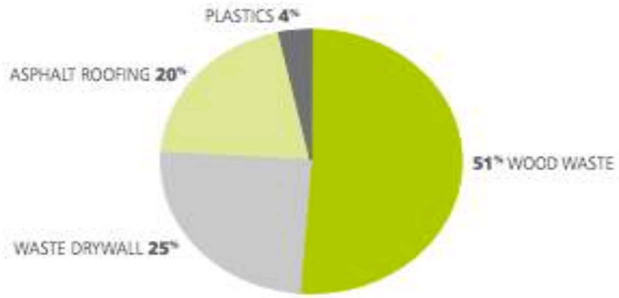


(RRFB, 2013)

Collection of data included the 7 major waste processing facilities in the province. Of the roughly 306,645 tonnes of waste produced per years in Nova Scotia, 46% is processed at the Otter Lake Landfill facility, which services the HRM (RRFB, 2013) (Refer to Appendix A, Figure 3). Certain materials within Nova Scotia's waste composition have unique potential in being incorporated back in sustainable construction practices. Detailed by the RRFB, specific materials in our waste stream are less commonly recycled/composted or are difficult to market (RRFB, 2013). Based on the HRM being the most active waste production region in the province, it is a useful jurisdiction to examine the potential for waste repurposing.

Construction and Demolition Waste Management in the HRM

Although C&D waste only represents 5% and 6% respectively in Nova Scotia's latest ICI and Residential waste audit (RRFB, 2012), *Our Path Forward 2011* reports that in actuality C&D waste accounts for 25%-30% of the total waste produced in Nova Scotia (Government of Nova Scotia, 2011). Excluding concrete and mixed rubble, C&D waste in the province consists of 51% waste wood, 25% waste drywall, 20% waste asphalt roofing, and 4% waste plastics (Government of Nova Scotia, 2011). Diversion of C&D waste from landfills across the province is variable, because of the Municipal Government Act (MGA, 1998, ss. 49, 81, 325-326), which allows for municipalities to form their own policies and by-laws for objectives towards diversion targets. In municipalities with strong diversion targets, like the HRM at 75%, there is significant potential to increase recycling/reuse of these materials into value-added uses (HRM, 2001). The HRM also enforces bylaw S-602, requiring all C&D waste generated within the region to be processed within HRM's municipal boundaries at certified facilities (Davidson, 2011).



(Government of Nova Scotia, 2011)

Demolition is common practice within the HRM, and typically produces 20-30 times more waste than a new construction (Consultation Notes, 2013; Jeffrey, 2011). Demolition is considered the manual or mechanical dismantling of a building, and where homes are concerned, it is a fairly simple process when waste material quality and sorting is not of high concern. It is estimated that renovation and demolition projects together produce approximately 90% of a nation's C&D waste, or 9.8 kg for each m^2 demolished (Agamuthu, 2008).

Waste material that is generated from the C&D industry within the HRM is subject to a tipping fee upon arrival at either of the two municipally approved C&D waste processing sites, managed by Halifax C&D Recycling Ltd.. C&D tipping fees are rates that one must pay per tonne of waste when they wish to dispose of materials at a processing site. Given the HRM's diversion percentage targets, and mandatory processing laws within municipal boundaries, all waste producers are subject to the rates established by Halifax C&D Recycling Ltd. Halifax C&D Recycling Ltd. tipping fees range from $10.00/tonne for Asphalt/Brick/Concrete waste, to $115.00/tonne for any mixed loads containing two or more waste C&D materials (Halifax C&D Recycling Ltd., 2013b). Clean asphalt shingles and clean wood are $75.00/tonne (Halifax C&D Recycling Ltd., 2013b)(Refer to Appendix A, Figure 4).

The Jeffrey study (2011) developed a snapshot of the current state of C&D waste repurposing/recycling in the HRM (Refer to Appendix A, Figure 5). Although the state of C&D processing in the municipality has not changed much since 2011, a few notable changes have occurred since the study (2011). RDM Recycling, a former C&D waste processing site within the HRM, has closed its doors until further notice (Dexter, 2013). As well, two test projects have been conducted using crushed gypsum board. One used crushed gypsum a soil amendment, and the second is using gypsum as an antibacterial agent in animal bedding, currently underway through Halifax C&D Recycling Ltd. (Consultation Notes, 2013).

Asphalt shingles represent 20% of Nova Scotia's C&D waste, and within the HRM, are separated in to two separate materials, asphalt sand and asphalt paper (RRFB, 2012). The asphalt sand is sold for use in hot mix asphalt pavement and the paper is sold as a fuel replacement for coal at the Lafarge Cement facility (Consultation Notes, 2013). Halifax C&D Recycling Ltd. processes between 8,000 and 12,000 tonnes of asphalt shingles per year for these purposes, where other municipalities mostly dispose of shingles in landfill or use as daily cover (Consultation Notes, 2013).

Gyprock (drywall) that arrives on site is de-papered and processed where it is then shipped out of province for manufacturing in new wallboard; metals are sorted on-site and recycled locally (Halifax C&D Recycling Ltd. 2013). Aggregates, which can contribute substantially to the total weight of wastes from a demolition site, are mostly used as topfill and have selective applications recycled into fill for roads and buildings (Consultation Notes, 2013; Jeffrey & Owen 2012)

Waste wood, which represents 51% of Nova Scotia's C&D waste, is classified as clean, or dirty/contaminated wood (Government of Nova Scotia, 2013a). The large amount of waste wood is a result of Canada having a very similar home building composition as the United States, where 90% of homes are wood-framed (PMI, 2013). Wood uses in construction vary dramatically, from structural components, to flooring, roofing, aesthetic pieces, and much more. "Clean" wood typically refers to untreated, sawn lumber to which no glues, adhesives, plastics, or resins have been added. "Clean wood" makes up the large majority of waste wood in the HRM (Consultation Notes, 2013).

"Dirty" wood, or "Contaminated" wood, includes engineered wood products to which glues and resins have been added, as well as wood products with paints or stains applied (Jeffrey, 2011). Engineered plywood, particleboard, and laminated wood products are examples of what can be considered "dirty wood", but are typically not as toxic as formaldehyde-based resins and lead paints (Jeffrey, 2011). Treated wood also makes up a percentage of contaminated wood. There are four categories of chemical treatments for wood: waterborne preservatives, including chromate copper arsenate (CCA), and oilborne preservatives, which include chemicals like pentachlorophenol, creosote, and fire-retardants (Bill Hinkley Centre, 2012). CCA represents approximately 80% of the wood preservation market and is used to prevent wood degradation from insects and fungus (Bill Hinkley Centre, 2012).

CCA wood, pressure treated wood decking, etc., typically represents 1% of the waste wood processed within the HRM (Consultation Notes, 2013). Since North American production of CCA wood was mostly phased out by 2004, it is expected that disposal rates of CCA wood will tail off by 2020 as CCA wood structures are decommissioned (Bill Hinkley Centre, 2012).

"Clean" wood in the HRM is chipped and sold as biofuel, topfill for Otter Lake, or animal bedding (Consultation Notes, 2013). Although most "contaminated" wood is used as topfill, a percentage can be sold as biofuel because Nova Scotia Environment allows a contamination rate of 10% in biofuel mix (Jeffrey, 2011). “Contaminated” wood that is chemically treated is currently landfilled or used as topfill (Consultation Notes, 2013). Of the roughly 22,000 tonnes of wood chips produced per year, 12,000 tonnes are used as topfill, and the remaining 10,000 tonnes are divided between biofuel and animal bedding (Consultation Notes, 2013)(Refer to Appendix A, Figure 6).

Existing C&D Salvage Market in the HRM

Select examples of waste material use in construction practices do exist in the HRM, however, formal systems and frameworks for the supply, support, and market of waste C&D materials in residential construction has not developed (Consultation Notes, 2013). Ad hoc examples of salvaging large timbers, hardwood, bricks and masonry exist, but are hardly advertized or promoted to a large degree (Consultation Notes, 2013). The existing recycled building material market is mostly segregated to two local businesses and a handful of design professionals that include waste material in their designs. The HRM did have four operating used building material stores at one time, only two remain: Renovators Resource, and the Habitat for Humanity ReStore.

Renovators Resource Inc. opened in 1994 and is mostly based around the sale of used building materials salvaged from heritage homes and fine architectural pieces (Renovators Resource, 2013). Their retail storefront (5,000 sq. ft.) features a wide variety of salvaged materials, such as doors, mantles, handrails, chairs, church pews, trim, radiators, plumbing/electrical fixtures, window frames, furniture, and other various pieces (Refer to Appendix A, Figure 7). The Renovators Resource philosophy is to “preserve and enhance our building heritage” and they do so by:

- educating homeowners and contractors about the environmental benefits of reusing building materials;
- providing an outlet for low-cost retailing of reclaimed building materials;
- dismantling structures to make the most effective use of reusable material;
- showcasing innovative reuses of building materials.

(Renovators Resource, 2013)

Their product base is procured from a variety of sources. The vast majority of their material is donated, personally sourced and dismantled, or purchased through salvage agreements with demolition professionals in the region (Consultation Notes, 2013). They procure materials through demolition projects by negotiating a price with demolishers to have Renovators Resource staff carefully remove desired materials from buildings prior to demolishing (Consultation Notes, 2013). Although these arrangements do divert useful materials from landfill towards remodeling, architectural, and aesthetic uses in homes, the financial burden of salvaging in this manner makes for very sensitive profit margins when trying to develop a recycled material market. Because of these sensitive profit margins, Renovators Resource services mostly a niche market of heritage home salvaged material and wood/metal work of higher value, not raw materials from consistent building decommissioning sources. Despite these challenges, Renovators Resource has been successful and has close ties with architectural pioneers Solterre Design.

Most direct local waste material reuse projects can be found in work by Solterre Design, an architecture firm located in the HRM who specialize in energy efficient design, passive solar architecture, resourceful renovations, and green design consulting. Solterre recently completed the Concept House, an off-grid LEED Platinum Certified and PassivHaus Certified home that features large amounts of waste materials (Consultation Notes, 2013). Regional homes like Solterre Design's Concept House that have incorporated large amounts of waste material in new construction will be featured later in this report as a regional best practice example of waste material use.

The Habitat for Humanity ReStore in Dartmouth is one of almost 100 ReStore's across Canada (Habitat for Humanity, 2013). As a whole, ReStore's occupy around 775,000 sq. ft. of store space across the country, and focus on the sale of high quality building supplies, home furnishing, appliances, and décor (Habitat for Humanity, 2013). The Dartmouth location has a large selection of windows, doors, flooring, cabinetry, trim, molding, paint, lighting fixtures, tables vanities, and much more (Refer to Appendix A, Figure 8). The revenue generated from the ReStore is almost entirely directed towards Habitat for Humanity build projects for local families needing safe and affordable housing. Unlike a private business, the ReStore can incentivize material donations because of the tax receipts they can offer as a charitable organization. When material is donated, the items are tracked for the fair market value they sell for, and tax receipts are then awarded to the individual, business, or donator (Consultation Notes, 2013).

The supplies available in ReStores differ greatly based on the sourcing ability of their staff. Due to a proactive and dedicated staff, the Darthmouth ReStore has successfully diverted over 900 tonnes of materials towards construction uses that would otherwise have been put in landfills (Consultation Notes, 2013). Most material that is donated and sold through the Dartmouth ReStore comes from renovation project wastes, lightly damaged pre-consumer goods, end-of-stock goods, and a small amount through demolition/deconstruction donations (Consultation Notes, 2013). Much like Renovators Resource, large amounts of raw building materials are not typically sold through this business, even though a significant demand was noted among numerous customers (Consultation Notes, 2013). Having only a staff of two full-time employees, the success of the Dartmouth ReStore depends on a crew of roughly sixty volunteers. It would be impossible to expect an already over-achieving business of this type to pioneer the widespread development of a large-scale recycled material market on their own, however, the potential they have already shown presents promise towards recycled market development.

Waste Tires in Nova Scotia

Canadian tire recycling strategies resulted from the aftermath of a crisis in 1990 that caught national attention. On February 12th, 1990, 12.6 million tires caught fire in Haggerville, Ontario (CATRA, 2006). The seventeen-day uncontrollable fire forced the evacuation of 1,700 people as a result of the immense toxic fumes emitted from the blaze, caused massive contamination of nearby water wells, and revealed the true environmental and safety issues that result from stockpiling waste tires (CATRA, 2006). Besides posing significant threats for toxic fires, tire piles also promote the spread of disease as they act as ideal breeding grounds for mosquitoes and vermin (St. Pierre, 2013). Although waste tires were banned from landfills April 1st, 1996 through Nova Scotia's Environment Act (1955), a useful recycled material solution was not developed until 2009.

The RRFB manages the Used Tire Program, one of the six recycling programs implemented by the RRFB (RRFB, 2013). The Used Tire Management program requires distributors and retailers of on-road passenger tires within the province to have a stewardship agreement with an RRFB administrator. Within the stewardship program, distributers agree to collect an environmental fee for every tire they sell within the province (RRFB, 2012b). The fees per tire range from $3.00 to $9.00 based on rim size, and the fees enable the RRFB to support the costs involved with the collecting and processing of the tires (RRFB, 2012b). Through a series of professional consultations and stakeholder discussions, a provincial interdepartmental committee decided that tire derived aggregate (TDA) was the most cost-effective and environmentally sound strategy to waste tire management in the province (Nova Scotia Environment, 2008). Under contract with the RRFB, Halifax C&D Recycling Ltd. processes all recovered passenger tires in Nova Scotia into TDA (Halifax C&D Recycling Ltd., 2013c). In 2012, the RRFB boasted a 90.9% recovery rate of tires, resulting in around 1.18 million tires being diverted from landfills (RRFB, 2012b).

TDA is the 100% recycled content product resulting from a tire processing system that shreds tires in to an aggregate, which ranges in size from 25mm to 300mm (1 to 12 inches) (Nova Scotia Environment, 2008). TDA in the HRM is produced in two forms: Type A, which is typically three inches or less, and Type B, which is twelve inches or less (Humphrey, 2011) (Refer to Appendix A, Figure 9). TDA has several unique properties; it is lightweight (a third the weight of soil), has a low earth pressure (half that of soil), is a good thermal insulator (eight times better than soil), has good drainage (ten times better than soil), and is compressible (Humphrey, 2009). The unique properties of TDA make it an excellent material for use in engineering applications such as slope stabilization, road insulation, lightweight embankment fill, vibration mitigation, and other various fill purposes. Several studies conducted through the University of Maine and the State University of New York at Buffalo have more than proven its viability in these applications (Humphrey, 2011; CIWM Buffalo, 2012).

The Centre of Integrated Waste Management at New York State University in Buffalo has developed some of the most innovative applications of TDA, using the recycled material as an insulation/drainage medium around home foundations (CIWM Buffalo, 2012). TDA use in this application already exists; however, their current development of R-value and performance data for TDA in this capacity has great promise. The potential behind this type of development in Nova Scotia is significant.

Existing Use of TDA in the HRM and Nova Scotia

There are very few examples of TDA being applied for its intended uses around the province. Most private projects that have applied TDA in the province have been ad hoc (Consultation Notes, 2013). Government projects have rarely include TDA in the place of traditional aggregate where TDA could be a very useful and cost effective replacement. The hesitation of TDA use seems to be attributed to the fear of TDA characteristics, lack of knowledge of its uses, lack of knowledge of availability, and no incentive for its use (Consultation Notes, 2013).

One of the most pioneering applications of TDA in the region was through Solterre Design's application of TDA around the foundation of the new Valley Waste Resource Management facility in Kentville, Nova Scotia. 100 m^3 of TDA was used around the foundation of the building for its insulation and drainage properties (Consultation Notes, 2013). This project was one of the first in the province to use TDA in this regard. One of the largest uses of TDA in Atlantic Canada saw the application of 1.6 million tires for landslide stabilization in St. Stephen, New Brunswick in 2008, however, this example has not stimulated a market for TDA use (Humphrey, 2009). Although the province has devised a solution for waste tire piles and the problems they create, Nova Scotia still faces a similar issue where TDA is now stockpiled instead of tires (Consultation Notes, 2013) (Refer to Appendix A, Figure 9).

Stakeholder Consultations

In order to develop an industry perspective on the actual or perceived barriers that exist with the potential development of a widespread recycled building material market, knowledge had to be obtained from stakeholders who may be vested in the development of such an industry. As the Halifax Regional Municipality (HRM) is the largest waste-producing region in the province, and has high diversion standards for C&D materials, stakeholders in the HRM were specifically targeted.

The criteria used for selecting which local stakeholders to consult was guided largely by the United States Environmental Protection Agency report titled *Developing Markets for Recyclable Materials: Policy and Program Options* (1993), and by case studies and reports dealing specifically with used building material market development (USEPA, 1993; Schübeler, Wehrle, & Christen, 1996; Kernan, 2002; Kane Consulting et al., 2012, BMRA, 2013; Hess, 2013).

Successful recycling markets depend primarily on:

• an adequate, reliable, and relatively clean supply of secondary (waste) materials;

• demand by processors (those involved in cleaning, pulping, grinding, and other forms of material preparation), manufacturers, and exporters large enough to absorb the supply of secondary materials; and

• consumer demand for products containing secondary materials sufficient to absorb the supply.

(USEPA, 1993)

To focus on the three vital components to a recycled material market specific to residential construction, input was compiled from stakeholders in the HRM through consultation sessions. Contributing stakeholders included:

- Waste Managers/Processors
- Architects
- Engineers
- Provincial Officials
- Organization Directors
- Consultants
- Council Directors
- Bureau Representatives
- Construction Contractors
- Demolition Contractors
- Recycled Material Retailers
- Business Owners
- Building Code Officials
- Academics

Consultation sessions varied slightly in their focus based on the stakeholder taking part in the session, however, sessions generally surrounded waste material potential in residential construction, current residential construction practices, current knowledge, and issues/concerns on the subject of waste material use in residential construction. Stakeholders were encouraged to expand on issues where they saw fit.

The following tables represent a summary of findings from the consultation sessions. Each table is divided in to issues/concerns surrounding either the supply of waste materials, processing of waste materials, or demand for waste materials. The materials of focus, C&D (mostly wood), and waste tires (TDA) were represented in separate tables to demonstrate the different obstacles that can exist in reusing materials for residential construction purposes that are subject to differing provincial/municipal waste management strategies.

Summary of Findings: C&D-Wood

Component	**Issue/Concern/Barrier**	**Detail**
Supply	*Building material salvage is ad hoc*	Individuals or small businesses that are individually driven to salvage perform all existing material salvaging. No formal policy, regulatory framework, or program exists in the HRM or Nova Scotia that promotes salvaging of building materials. It is not efficient and is economically challenging to expect small businesses or individuals to source waste materials alone in the fast-paced industries of residential construction and demolition.
	Demolition is common practice	Most building decommissioning professionals in the region demolish instead of deconstruct homes. Although this process is cheaper and quicker given the policy framework in the HRM (and NS), there exists very little potential for the reuse of materials because the quality of materials are vastly decreased and there is limited sorting potential with this decommissioning strategy.
Processors	*Tipping fee not sufficient incentive for sorting*	Stakeholders involved in construction or demolition usually equate the cost in sorting, storing, and transporting multiple waste bins as being more than the cost of mixed load tipping fees. Regional tipping fees have not been incentive enough to promote widespread sorting.
	Material has degraded in quality upon arrival at waste processing sites	Due to exposure to elements (hot, cold, mold, moisture, etc.), material that could potentially be directly repurposed has already degraded beyond potential use by the time it has arrived at a C&D processing site.

	Engineered wood market undeveloped in the region and in Nova Scotia	Where material may not be salvageable, but could potentially be kept clean and sorted, engineered wood producers don't exist in the province to use this waste material in a recycled content product.
Processors	*Discouragement amongst processors*	Efforts have existed in the past to manually sort materials at C&D sites for resale, but the cost of sorting material and incurring the brunt of responsibility of this system led has led to disenchantment because of the lack of support from provincial and municipal bodies.
Consumers	*Economic concerns with price of reused wood*	Often times salvaging involves labor hours to prepare wood for reuse (removing nails, strapping, paint, bindings, sawing chipped ends, etc.). With relatively low costs for virgin lumber, and no economic incentive for using salvaged lumber, salvaged lumber needs to be a cost-effective alternative to be viable.
	Coding concern with the use of salvaged material	There exists an unfounded fear of application of salvaged material in home construction. Some stakeholders involved in construction/design of homes have a strong reluctance to use salvaged materials in building around the fear of a home not meeting code.
	Lack of availability and knowledge of salvaged building materials; lack of demonstration examples	Stakeholders who would be consumers of salvaged materials note that there is a lack of available salvaged material to even consider developing a regular standard for salvaged material incorporation in home design. Where limited amounts of salvage materials do exist (Renovators Resource, Habitat for Humanity ReStore, etc.,), viable stakeholders are not aware of the materials available through those retailers or the services they can offer upon request. Homes that have reused/recycled components have not been highlighted as demonstration homes to serve as public examples.

	No provincial or municipal incentive for the use of reused or recycled content material in residential construction	Home standards in Nova Scotia are geared towards home efficiency, and pay little to no attention to material inputs. The handful of LEED (Leadership in Energy and Environmental Design) Homes in the province and ad hoc projects using waste materials have been motivated by consumer stewardship, and not provincial or municipal incentives.
All Components	*Lack of education around the environmental, social, and economic benefits of salvaging building material*	Although most stakeholders assumed through rational thought that the benefits of salvaging material overall are positive, most were unaware of *why* or *how* system benefits could be seen.

(Consultation Notes, 2013)

Summary of Findings: Tire Derived Aggregate

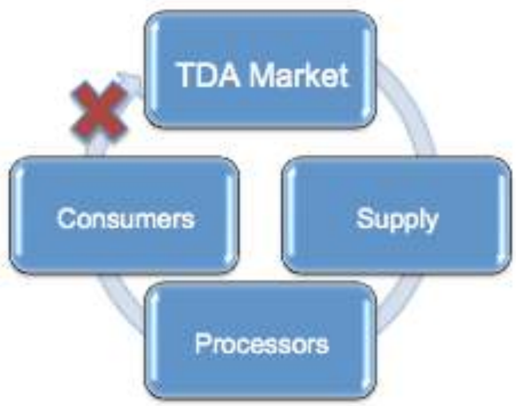
Component	**Issue/Barrier/Concern**	**Detail**
Supply	*No issue – material is abundant*	Nova Scotia diverts between 900,000 and 1,200,000 passenger tires from landfill. The volume and quantity of tires in the province is consistent and policy is well developed for the diversion of waste tires.
Processors	*No issue – Nova Scotia is in contract for the production of TDA with Halifax C&D Recycling Inc.*	Halifax Construction and Demolition Inc. is in contract with the province of Nova Scotia to process all passenger tires towards the production of TDA. The framework and legislation in place for the collection and processing of waste tires has resulted in an abundant supply of TDA in the province, all of which is located in the HRM.
Consumers	*Lack of education amongst industry professionals around the uses of TDA*	Where education sessions to present the uses and benefits of TDA have occurred, they have not resulted in market uptake of the material. Most knowledge that does exist on the material is around its traditional uses (roadbed

		insulation, vibration mitigation, lightweight embankment fill, etc.,) and not for its more innovative uses (building foundation insulation, exterior drainage medium, septic bed drainage medium, geothermal line insulation). Some stakeholders did not know the province produced TDA.
Consumers	*Misconception of environmental concerns around the use of TDA*	Education sessions that have been conducted have not presented sufficient or appropriate case study and research documentation to dispel valid concerns surrounding the potential environmental effects of using TDA as a building material. Although significant research has been done on this topic, lack of focus in proving the use of TDA being an environmentally safe material has created a stigma of caution amongst industry stakeholders in the region.
	Fear of application due to the lack of regional case studies that have incorporated TDA and coding issues	Although TDA has more than proven its usefulness in other jurisdictions, lack of local use and demonstration of the material's uses has resulted in a hesitation by industry stakeholders to incorporate it in their projects. Pioneering projects that have used TDA, for the most part, have not been presented and shared as demonstration homes for educational purposes.
	No knowledge of availability or financial viability of TDA	Very few stakeholders were aware of how they could access TDA for their projects. In addition, most were also not aware that the material is currently free, and processors are encouraging projects to incorporate TDA for its intended uses.
	No provincial incentive for the use of TDA	No incentive programs exist for the use of TDA. Although incentivizing its use would not be the only policy option available to increase the uptake of TDA in the market, it could have significant effect.
	Intended provincial uptake of TDA has not occurred	It was intended that TDA would be included in provincial, commercial, and industrial tenders, however, lack of uptake has resulted in TDA being stockpiled and not consumed. It was noted that companies who have traditionally been involved in projects using the same materials for many years could be hesitant in incorporating different materials,

		like TDA, because it would not directly stimulate the local traditional economy.

(Consultation Notes, 2013)

Where two separate streams of waste materials are concerned (C&D waste wood and TDA), barriers in the HRM around the supply, processor, or consumer components of a recycled material market are very different. The reuse of C&D waste wood, a material *not banned* from landfills, has significant barriers around the supply, processor, and consumer components of a waste wood market for use in residential construction practices. Waste tires, a *banned* material from landfills, has no issues with the supply or processor components of a recycled material market, as provincial policy and strategies exist for the diversion of tires from landfills towards the production of TDA. However, significant consumer barriers exist with the use of TDA.



Although stakeholders have reacted very differently to the potential of a recycling market for these materials, solutions to these barriers are similar because the materials have common intended uses in residential construction.

Key Recommendations

Recommendation Framework

The following key recommendations were formed to provide potential solutions that could address the barriers that exist surrounding the development of a recycled building material market. The recommendations were formed to address the barriers revealed in the findings, and are based on both national and international best practice examples from case studies, policies and regulations, as well as consultations with successful recycled industry professionals in other jurisdictions. To target barriers either with supply, processors, or consumers, recommendations were framed as supply based policies, demand-based policies, or waste regulations dealing with supply and demand concerns.

Recommendation Framework
Supply-Based Policies
Demand-Based Policies
Waste Regulation (supply + demand)

Summary of Key Recommendations

Pilot Deconstruction Incentive Program

- Green Deconstruction Certification
- Expedited Deconstruction Permit
- Deconstruction Permit Cost Reduction
- Mandatory Salvaging Grace Period

Nova Scotia Green Building Program Pilot

- Operational Efficiency Targets
- Certified Material Selection
- Locally Sourced Reused/Recycled Material Selection

Recycled and Reused Material Education

- Tire Derived Aggregate Uses, Case Studies, and Promotion
- Reused/Recycled Material and Building Codes
- Deconstruction Training
- Efficiency Nova Scotia Demonstration Home Expansion
- Engineered Wood Product Development

Province-Wide Diversion Strategies

- Harmonized Municipal C&D Diversion Rates
- Increased C&D Tipping Fees
- Wood Ban

Supply-Based Policy: Pilot Deconstruction Incentive Program

Pilot Deconstruction Incentive Program

- Green Deconstruction Certification
- Expedited Deconstruction Permit
- Deconstruction Permit Cost Reduction
- Mandatory Salvaging Grace Period

Deconstruction, as defined by the Deconstruction Institute, is a process of manual building disassembly used to recover the maximum amount of materials for their highest value and best re-use potential (Guy, 2003). As a tactic for the decommissioning of homes or buildings, deconstruction has proved to be extremely beneficial for a variety of reasons. It is estimated that if the 250,000 homes decommissioned in the United States every year were deconstructed, 6,000 board feet of reusable wood along with countless other building materials could be salvaged to build 120,000 new affordable, single-family dwellings each year (Munroe & Hatamiya, 2006).

Proper deconstruction has several advantages. When carried out properly, deconstruction has been known to:

- Create a supply of lower cost building materials to businesses and communities
- Extend the life of landfills by diverting 75%, 90%, sometimes even 95% of waste from landfills towards reuse or recycling
- Protect the natural environment by reducing the need for the extraction of new resources through the reuse of existing materials
- Create jobs and economic development
- Increase public health and safety through careful removal and disposal of hazardous materials
- Significantly reduce the embodied energy of homes used with material from deconstruction projects

(Carruthers, 2013; Kernan, 2002; Guy, 2003, City of Cleveland, 2009; Kane Consulting et al., 2012; City of Chicago, 2013)

Although deconstruction has many advantages, it has disadvantages without a municipal or provincial support framework. Without support frameworks, common critiques of deconstruction surround increased total time to complete decommissioning projects, increased labor costs, lack of sorting space, lack of resale market, and lack of education around proper deconstruction practices. These issues are very common throughout national and international examples of deconstruction projects without supporting frameworks. In a local deconstruction case study conducted on the Dalhousie University campus, findings revealed that after the sale of salvaged materials, deconstruction projects cost 8-15% more than traditional demolition, and can take from 1-2 weeks longer to decommission an average home (Jeffery & Owen, 2012).

The proposed Pilot Deconstruction Incentive Program would involve four main components that would seek to incentivize *proper* deconstruction practices in the region to create a highly efficient building and home decommissioning program that would create an organized a consistent supply of waste materials for local businesses and individuals, local employment opportunities, high diversion rates of waste materials, and significant incentives for demolition businesses willing to invest their efforts in the pilot.

Green Deconstruction Certification: This certification would involve demolition professionals to attend certification workshops on proper building deconstruction practices. The certification system would be to ensure that homes are being deconstructed using the most sustainable methods possible. The incentive for decommissioning professionals in this program is to achieve municipal financial support for deconstruction projects that meet the established criteria of the program. The program would require building professionals who wish to decommission a building through deconstruction to submit an application package to the municipality that includes information on:

- **Building**
  - Type of building or home, types of wastes expected, volume of wastes expected etc.,
- **Planning**
  - Deconstruction strategy, demonstrate on-site storage and sorting of 75%-95% of materials (Jeffery & Owen, 2012), material tracking, number of employees required, timeline, estimated cost of deconstruction, etc.
- **Environmental Health and Safety**
  - Strategy for hazardous material management on-site and disposal, site contamination and dust mitigation strategy, etc.
- **Bonus Credits**
  - Innovative solutions for salvaged materials from building/structure (planned used in other construction projects, adaptive uses etc.)

Program adapted from Bradley Guy - Green Demolition Certification (Guy, 2006)

If the deconstruction package submitted met the requirements established, the municipality could subsidize a percentage of the costs incurred by the applicant for the deconstruction project. Throughout the project, a municipal auditor would be responsible for un-scheduled site visits based on the timeline of the project to ensure commitments in the deconstruction application were upheld.

An example of a viable bonus credit could be the diversion of waste materials from a deconstruction project directly towards the building of another structure. In the Netherlands, for example, *2012Architects* are regarded as some of the worlds most innovative home and building architects who pioneer home designs around reused and recycled materials. By sourcing materials through salvaged buildings within a 9 mile radius of their work site, they were able to build a fully modern, coded, efficient, and aesthetically pleasing home made up of 60% directly reused materials for the structure of the home, and 90% directly reused materials for the interior of the home (Szita, 2011). This home, named the Villa Welpeloo, more than exceeded the designer's goals of creating a modern home with using waste materials (low embodied energy), meeting code, and being low-cost (Refer to Appendix A, Figure 10).

This Green Deconstruction Certification program would target several issues revealed in the stakeholder consultations, where a consistent and clean supply of waste materials would be available for businesses and individuals to acquire, and would also track wastes from deconstruction projects to ensure no illegal dumping of waste materials occurred (Consultation Notes, 2013).

Expedited Deconstruction Permit: To address the disadvantage that deconstruction has compared to demolition in normally taking longer, the Pilot program would include an expedited permitting process. This process would accelerate the time a contractor needs to wait for deconstruction operations to begin, granted their required documents within the *Green Deconstruction Certification* program have been accepted. Accelerated permitting processes are common in proactive jurisdictions that have begun to address C&D waste issues. The Priority Green Program of Seattle, Washington, USA and The City of Vancouver, British Columbia are two examples of this, where both have city by-laws expediting deconstruction projects (Bowyer et. al., 2013; City of Vancouver, 2011).

Deconstruction Permit Cost Reduction: Along with expedited permitting processes within the *Green Deconstruction Certification* program, municipal permit processing costs would either be waved or significantly reduced. This recommendation has been made and implemented in several jurisdictions, such as San Diego, Cleveland, Chicago, and Vancouver (Bowyer et. al., 2013; City of Vancouver, 2013; City of Cleveland, 2009; City of Chicago, 2013). Some of these programs entirely wave deconstruction permit costs, and others subsidize deconstruction permits at 50% or more of normal demolition permit costs. Although this would not cover the typical 8-15% cost increase for deconstruction compared to demolition, it would be a component of the financial support municipalities could offer to incentivize deconstruction.

Mandatory Salvage Grace Period: Whenever the municipality issues demolition or deconstruction permits, an online information database would be made available to certified businesses detailing location of the project, materials available, and a salvage period for staff to come salvage materials. For projects involved in the Green Deconstructio*n* program, honoring the Mandatory Salvage Grace Period would earn the project bonus credits to increase their bracket of municipal assistance. For projects not involved in the program, mandatory salvaging would still apply. In jurisdictions with developed salvaging frameworks, significant benefits have been noted. In the UK, for example, 45% of their core C&D waste is diverted towards direct reuse or recycling thanks to programs such as the National Community Wood Recycling Project (NVWRP) (Van Benthem et al., 2005).

The NCWRP is a community-based enterprise that organizes wood reuse and recycling projects across the UK through a collection of small businesses. Through salvage agreements within separate municipalities, members of the NCWRP deploy staff to demolition or deconstruction projects to salvage useful wood stock to supply recycled building material storefronts (Consultation Notes, 2013). As a whole, they are gaining significant momentum whereby in 2012, the NCWRP diverted 8,510 tonnes of wood from landfill towards direct reuse in construction or furniture making, over 1,000 tonnes more than in 2011 (NCWRP, 2013; Consultation Notes, 2013). A business operating within the NCWRP, the Bright & Hove Wood Store, have been steadily growing over recent years because of the affordable prices they can offer contractors and craftsman, and the wealth of materials that are being made available to them (Consultation Notes, 2013). Because Bright & Hove have offer free pick up services for wood that can be relatively easily accessed, they also save building decommissioning contractors significant amounts of money that would be paid in tipping fees (Consultation Notes, 2013). Wood collected from their program is graded in-house in three separate grades, where grade 1 and 2 are used directly in construction capacities or furniture/artwork, and grade 3 wood is converted to wood chips for animal bedding or biofuel (Consultation Notes, 2013).

The State of California is also home to several municipalities that enforce mandatory salvage periods through building decommissioning contracts. Some cities, like Palo Alto, CA, incorporate significant waste diversion incentives in their city by-laws to work towards achieving the goals stated in their *Zero Waste Strategic Plan* (City of Palo Alto, 2005). Salvage businesses in California note that salvage grace periods do not only benefit the reused material market, but also decommissioning professionals who want to avoid increase tipping fee costs (Consultation Notes, 2013). Within the HRM, it was noted among stakeholders that even just the incorporation of a salvage grace period would drastically influence their businesses for the better.

Demand-Based Policy: Nova Scotia Green Building Program Pilot

> **Nova Scotia Green Building Program Pilot**
>
> - Operational Efficiency Targets
> - Certified Material Selection
> - Locally Sourced Reused/Recycled Material Selection

"Green" building programs, or "green" building certifications, are not new to the Nova Scotian residential construction industry. As is the case in Nova Scotia, most standard certification systems have typically catered to operational efficiency measures in homes, where jurisdictions have been most concerned with lowering the energy demand of the residential sector (Coldham & Hartman, 2006). In July of 2013, the province amended Part 10 of the Nova Scotia Building Code Regulation to fall in line with the National Building Code, which measures its energy efficiency achievement through the efficiency rating program "EnerGuide for New Homes" (Government of Nova Scotia, 2013c). This efficiency standard is subsidized by more than six provincially-funded efficiency programs for residents to retrofit existing homes or equip new homes with energy efficient products to achieve higher operational efficiency levels based on EnerGuide's 100 point rating system (Atlantic Green Building, 2013).

R-2000 is one of the more recognized building models in Nova Scotia, designed to lower energy consumption in new homes by 30% compared to baseline coding standards, at an increased cost of 2% - 6% (NSHA, 2013). The R-2000 home model was developed federally, and features continuous whole house ventilation, environmentally friendly building products, a continuous building envelope to reduce drafts and cold spots, energy-efficient appliances, lighting, doors and windows, higher levels of insulation, advanced heating and cooling systems, and a certificate from Natural Resources Canada (NSHA, 2013). Along with these components, R-2000 homes must rate a minimum of 80 on the EnerGuide system.

Although R-2000 and EnerGuide rated homes have the potential to incorporate recycled and reused materials, as a whole, they do not consider lifecycle implications of embodied energy in their design and are mostly still based on operational efficiency. Besides the six home efficiency programs through Efficiency Nova Scotia, provincial subsidies for R-2000 homes and others exist that are based on EnerGuide performance ratings and range from $2000 for homes that score 83-84, up through to $10,000 for homes that score 92 or over (Denim Home, 2013).

Where larger and more comprehensive home rating and building certifications are considered, the LEED certification is the most common in North America. The

Leadership in Energy and Environmental Design (LEED) program is a rating system that is recognized in over 132 countries and has certified or registered over 5,000 buildings in Canada over the past 11 years (CAGBC, 2013). LEED is a comprehensive point-based system where building projects earn LEED points within seven LEED credit categories: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Indoor Environmental Quality (IEQ), and Innovation in Design (ID) (USGBC, 2014). Depending on the rating of the building and where points were earned, LEED buildings can incorporate large amounts of reused or recycled materials. LEED ratings vary from being LEED Certified (40-49 points), LEED Silver (50-59 points), LEED Gold (60-79 points, and LEED Platinum (80+) (USGBC, 2014). In terms of energy efficiency, coding requirements within the province would relate to around a LEED Silver rating, but that doesn't necessarily consider other components of their system (Consultation Notes, 2013).

Although LEED does have a *LEED for Homes* certification, the vast majority of LEED certified buildings within Nova Scotia are provincial, institutional, or commercial buildings (CAGBC, 2014). There are many examples of these sectors adopting LEED certification minimums for their buildings as efficiency and environmental stewardship programs become more prevalent in their respective sectors. Nova Scotia currently has 14 registered *LEED Homes*, some which also pursue PassivHaus certification, a high-efficiency home rating program developed in Europe (CAGBC, 2014). Although these homes could receive funding by being EnerGuide rated, *LEED Homes* for the most part have not taken off in the province. This is most likely attributed to the fact that LEED projects cost $2,000 on average to be certified, and operational efficiency is the only component of homes incentivized by the province (CAGBC, 2014).

Instead of entirely recreating a home certification system, the proposed Nova Scotia Green Building Program would maintain the EnerGuide for Home's operational efficiency rating incentives, but develop a subsidy component for locally sourced materials, reused/recycled materials, and embodied energy considerations. *LEED for Homes* could be a good model for this type program, however, some building professionals note that LEED in general has become too single-attribute oriented in its allocation of points, and does not properly credit components within its rating scheme that should perhaps play a much larger role (Consultation Notes, 2013).

Regardless, in its most basic form, this program could incorporate requirements for a percentage of recycled or reused material to be included in various components of a homes construction. If a home demonstrated certain percentages of waste materials, low-embodied energy materials, and sustainable design components, they would be eligible for provincial or municipal subsidies. Even at the municipal level or province-sized level, small-scale home building certification programs have seen success in other jurisdictions.

The Nebraska Green Building Program operated for several years and saw over 130 homes within the state certified through their program that had minimum requirements for sustainable site development, recycled material content in foundation, building envelope construction, and interior finishing (Consultation Notes, 2013; NEO, 2007).

Many of these home components had mandatory levels of 50% recycled or reused materials, and market uptake was quite substantial for the years the program operated before amalgamating with a national green building program (Consultation Notes, 2013). Even city-wide programs such as the Austin Energy Green Building Program have seen success on a small scale, where they have 13 certified homes within their 5 star rating system (AEGB, 2014). In Austin's program, homes are awarded points based on sustainable site selection, operational efficiency levels, water conservation, material selection and resource conservation, and indoor environmental quality (AEGB, 2013).

Another option could be to adopt certain components of the publicly accessible International Green Building Code, which has proven to be a building block for some of the larger state-adopted sustainable building codes. One of the more recent coding amendments using the IGCC as a foundation was the 2011 Oregon REACH Code that incorporated a variety of sustainable building components in their 145-page code amendment (OBCD, 2012).

Many options exist for the potential development of a green building program in Nova Scotia. Whether the pilot program adopts an actual green building certification framework, code amendments, or simply incentivizes the use of quality salvaged material in homes, significant amounts of material currently used for very low-value repurposing could easily be diverted towards more sustainable construction practices in the municipality and province. This concept would be most well received through stakeholder engagement of building professionals, design professionals, city planners, municipal/provincial officials, coding officials, and even waste management professionals to develop a program that is understood and clear in its intention through all sectors.

Demand-Based Policy: Recycled and Reused Material Education

Recycled and Reused Material Education

- Tire Derived Aggregate Uses, Case Studies, and Promotion
- Reused/Recycled Material and Building Codes
- Deconstruction Training
- Efficiency Nova Scotia Demonstration Home Expansion
- Engineered Wood Product Development

Tire Derived Aggregate Uses, Case Studies, and Promotion: Educational workshops have been conducted in the province, but have not been sufficient to address the concerns that industry professionals have with the uses of TDA. It would be beneficial for the province to develop more effective workshops for the intended uses of TDA (road bed insulation, vibration mitigation, etc.), but also for its more innovative uses (infill/backfill for foundations, septic bed filtration, geothermal line insulator). These types of workshops would include case study presentation of TDA, as well as examples of where it has been applied for innovative purposes. A significant database of open source studies exists through the Centre for Integrated Waste Management Buffalo that have countless reports and information available on the uses of TDA (CIWMB, 2012). The CIWMB are considered pioneers in TDA research, and have current cutting-edge studies further validating the thermal performance of TDA around foundations (CIWMB, 2012). Also included in these sessions would be an environmental component that presents the significant work that has been done to prove that the environmental effects of TDA are considered negligible in most every dimension studied (leaching, groundwater contamination, offgassing, etc.) (CIWMB, 2012).

Within the recycling program of the State of California, CalRecycle, an entire grant program devoted to promoting the use of TDA exists to increase the recycling of California-generated waste tires (CalRecyle, 2012). The program offers financial support to industry, municipal, or state professionals that wish to incorporate TDA in their projects to replace traditional materials. In many building codes and programs, R-2000 included, addressing foundation heat loss is a priority. Where TDA is a very high-performing insulator and is an excellent drainage medium, Efficiency Nova Scotia could consider incorporating a TDA grant to equip existing or new homes with exterior foundation insulation. Nova Scotia may want to consider this type of program to increase the industry application of TDA in the province.

Reused/Recycled Material and Building Codes: Contrary to the fears of some industry professionals, "unless otherwise specified, used materials, appliances and equipment are permitted to be reused when they meet the requirements of the Code for new materials and are satisfactory for the intended use" (Government of Canada, 2010). This excerpt from the National Building Code of Canada, a code adopted by Nova Scotia, lays to rest the misconception that reused materials cannot be salvaged and reused in homes. However, for structural components of a home (studs, headers, top/bottom plates, wall joists, load bearing members, etc.) material "shall possess the necessary characteristics to perform their intended functions when installed in a building" (Government of Canada, 2010). Materials used in these regards have to either have been graded at some point and upon inspection are considered to still be able to serve their intended function, be re-graded, or be signed off and stamped by an engineer (Consultation Notes, 2013). To preserve the quality and function of material, the careful handling of reusable materials in deconstruction practices are vital.

Some jurisdictions that salvage deconstructed graded wood material, non-graded wood material (typically pre-1950 structures), and urban wood waste (urban trees), hire on-site wood graders who can re-grade wood (CalRecycle, 2011). In some cases, fire resistance grading also must be considered. This option might be viable in the HRM if deconstruction projects could incorporate funding for wood grading. If a contractor was not comfortable with using already graded salvaged wood, or even regarded salvaged wood, home components like sheathing, trim, and sub floor do not require graded wood in construction and salvaged wood could be diverted to those components (Consultation Notes, 2013).

Coding concerns around recycled materials, like recycled cellulose insulation, have significantly deteriorated in recent years, where recycled cellulose insulation is now commonly used around the province (Consultation Notes, 2013). As highlighted in the RRFB Nova Scotia Glass Study (Hood, 2006), post-industrial crushed waste glass has been slowly incorporated in to concrete mixes to replace traditional aggregate, sometimes even over 20% total mix weight (Consultation Notes, 2013). Codes have accommodated to this, largely because of the widespread acceptance and pioneering code adaptations from other jurisdictions. Crushed waste glass used as a 100% replacement for septic bed filter aggregate has also begun in the province. Since Nova Scotia ships the majority of waste glass out of the province, and is an inert material, storing waste glass to be consumed in concrete mixes or septic beds seems like a much more environmentally sound and economically feasible solution to waste glass management.

Where TDA is concerned, the State of New York has already approved in their code the use of TDA as a septic bed medium replacement, allowing for easy adaptation from industry professionals who have coding concerns for the material (NYSDH, 2010). In one of the first examples of TDA being used as insulation and filtration around a building foundation in Nova Scotia, the Valley Waste Resource Management facility designed by Solterre Design had specs drawn by Stantec to be approved by code (Consultation Notes, 2013). Alleviating coding concerns among building professionals through workshops and coding adaptations would be a very cost-effective and simple method to ease the application of reused material in residential construction practices.

Deconstruction Training: Because the supply of quality, safe, and cost-efficient waste material depends on the proper deconstruction of structures, offering municipally funded deconstruction training would be a very beneficial service to offer. Not only would the municipality ensure safe and effective dismantling of structures that would create a wealth of useful waste building materials, job creation would be substantial. The National Community Wood Recycling Project of the UK provided 13,358 days of employment and training through their deconstruction and salvage services in 2011 alone, catering mostly to disadvantaged workers (NCWRP, 2013).

The Deconstruction Institute based in the United States has a well developed deconstruction training curriculum that is highly regarded within the decommissioning industry, however, select professionals within the HRM also have the required skill-sets to conduct deconstruction training workshops.

Efficiency Nova Scotia Demonstration Home Expansion: Efficiency Nova Scotia currently operates a demonstration home program to highlight modern examples of homes built in the region that demonstrate the provinces advanced building strategies towards energy efficiency. This program does an excellent job in highlighting the provinces financial incentives for having homes EnerGuide rated for 80+ to achieve incentives, and very accurately details the benefits of EnerGuide and R-2000 homes. Within the Efficiency Nova Scotia *Demonstration Homes Build Smart – Live Right* magazine, two flagship, high-efficiency homes are promoted (Efficiency Nova Scotia, 2011). The features of note within these flagships homes are their high EnerGuide ratings, wall design, insulation, windows, photovoltaic systems, water and energy efficiency measures, and local material selection. With lifecycle considerations in mind, local material selection is obviously ideal, however, the only recycled component advertised in the flagship homes is recycled blown in cellulose insulation. For the province to expand consumer awareness of the potential that recycled and reused materials have in home construction, just as it has effectively done with promoting energy efficiency, it is recommended that homes in the province that have demonstrated high efficiency along with large amounts of recycled material use be added to the demonstration home program. An example of this could be the Concept House by Solterre Design.

The Concept House, along with being the first LEED Platinum Certified home in Nova Scotia, is also PassivHaus certified (Consultation Notes, 2013). Compared to the 30% efficiency R-2000 homes boast, PassivHaus certified homes use 70-90% less energy than a typical home of the same size, and are designed to capture passive solar energy to never drop below 15 degrees Celsius without a heating system (Solterre Design, 2012). The combination of the two certifications make it not only an extremely energy efficient home that would achieve the highest EnerGuide rating, but a home that has incorporated a massive amount of low-embodied energy, recycled, and reused material.

The following tables demonstrate the scale of reused, recycled, and renewable materials used within the 3 bedroom, 2 bathroom home, off-grid home.

Salvaged Material	Salvage Location
Doors	Thornvale House Salvage
Kitchen sink	Northwood Manor
Island cabinet	Old Grace Maternity Hospital
Stainless steel island	Mother House Convent
Timber window sills	c.1800 cape on 1st Peninsula
Stainless fireplace surround	Northwood Manor shelving
Shower surround	Waste signage from New Century Signs
Aluminum artwork	Sign scrap from New Century Signs
Copper vanity	Roof from Stanbury House
Walk-in closet paneling	60's home renovation in Halifax
Wall trusses	"My Little Eye" movie set
Foam under green roof	Roof renovation in Burnside
Light fixtures	Various old buildings
Shed windows	Garbage salvage

(Solterre, 2012)

Renewable Material/Energy	Purchasing Location
Framing lumber	Saw mill in Elmsdale N.S.
EPS foam, Prefab slab form	TrueFoam, Dartmouth Nova Scotia
Recycled Cellulose Insulation	Thermocell, Dartmouth Nova Scotia
Solar Hot Water Panels	Thermo Dynamics, Dartmouth Nova Scotia
Straw Board Built-ins	Discontinued Supply, New Orleans
9- Panel PV Array	Nova Scotia - 1.89 Kw

(Solterre, 2012)

Recycled Materials	% of Recycled Content
17 ton. crushed glass as aggregate	100% pre-consumer
72 ton. crushed glass septic filter	100% post-consumer
500 bags cellulose insulation	75-85% recycled
Rainscreen spacer	100% post-consumer plastic
Galvalume roofing	30% recycled content

(Solterre, 2012)

Other features of note within the home are: torrefied wood siding, cement fiber siding fiberglass/aluminum windows, living roof system, diamond ground concrete flooring, roof waster cistern collection, low-flow shower and toilet, DC appliances, high-efficiency ERV, and low-emission materials (Solterre, 2012). Admittedly, Solterre Design intentionally went to some extreme lengths in certain areas of the home to prove that reused, recycled, and low-embodied materials can meet high efficiency requirements in a very modern, aesthetically appealing, and cost-effective home (Consultation Notes, 2013). Significant monitoring systems have been installed in the home to further prove the function of the recycled and reused materials in the home, and the thermal performance of the systems/designs.

A home like the Concept Cottage far exceeds Efficiency Nova Scotia Demonstration Home efficiency levels, and incorporates massive amounts of locally acquired salvaged and recycled materials. Since local professionals have the skill-sets and ability to build homes to be extremely efficient while using incredibly low embodied energy reused and recycled materials, it would seem like a very worthwhile venture to promote these types of homes through the Efficiency Nova Scotia Demonstration Home program (Refer to Appendix A, Figure 11).

Engineered Wood Product Development: Currently, there are no engineered wood manufacturers in Nova Scotia (Consultation Notes, 2013). Although not all engineered wood products, like finger-jointed wood, could utilize waste materials, some have great potential. The Netherlands, Belgium, and the UK, three of Europe's largest C&D waste producers, are also two of the top-performing jurisdiction for C&D waste reuse and recycling. Of the "core" C&D waste produced, the Netherlands reuses or recycles 90%, Belgium 87% and the UK 45% (Van Benthem et al., 2005). In the Netherlands, for example, a contributing factor to their high reuse and recycling percentages is the diversion of waste wood towards the production of pallet blocks and single use pallets of pressed wood. Waste wood in the country is graded A, B, or C. A-grade waste wood goes towards the production of this recycled pressed wood (36%), B-grade wood is used as bioenergy fuel (58%), and C-grade wood is exported as biofuel to other jurisdictions (Van Benthem et al., 2005).

FPinnovations, a Canadian not-for-profit research centre working in forest research, has noted the potential for waste wood material to be possibly used in wood-fiber insulation (undergoing testing in recent years), fiberboard, and even possibly used in cross laminated timbers (CLT's) (Consultation Notes, 2013). For any of these options, however, a clean and quality supply of waste wood would be pivotal to the potential application of waste material in these engineered products.

Although engineered wood products do depend on a manufacturing process, they could potentially contribute to the development of value added uses for waste wood that cannot be directly repurposed as-is before being chipped and sold as biofuel, or used as topfill/disposed in landfills.

Waste Regulation: Province Wide Diversion Strategies

Province-Wide Diversion Strategies

- Harmonized Municipal C&D Diversion Rates
- Increased C&D Tipping Fees
- Wood Ban

Harmonized Municipal C&D Diversion Rates: Allowing municipalities to establish their own C&D targets and diversion programs within Nova Scotia has allowed for ambitious municipalities to develop strong waste management foundations, however, lack of harmonization among municipalities is now seen as a hindrance to the widespread success of C&D waste management within the province (Consultation Notes, 2013). Illegal dumping between municipalities to avoid more expensive tipping fees has been a growing concern among provincial and municipal officials as more municipalities attempt to bolster their C&D waste management programs (Consultation Notes, 2013). Officials have begun to attempt developing a program that would track C&D waste from sites that would include volumes of materials and where they were disposed of, however, without harmonized diversion rates within municipalities, industry uptake of the program has been said to be unlikely (Consultation Notes, 2013).

If a harmonized C&D Diversion Rate program could be administered in the province, there would be the potential for increased tracking and management of materials that are improperly disposed of. This would also lead to increased stewardship of waste creation, and an inevitable development of responsibility among industry professionals to be conscious about the wastes they produce, materials they use, and materials they could reuse or recycle. This type of program would most likely have to be a grandfathering process, whereby municipalities would increase diversion targets over a 10-year ($^{+}/_{-}$) span, to gradually match the established target across the province.

Increased C&D Tipping Fees: Pursuant to a harmonized C&D diversion rate among the municipalities in Nova Scotia, an increased C&D tipping fee has the potential to further promote the diversion of waste materials from landfills towards reuse and recycling. Internationally, countries that demonstrate some of the most advanced diversion rates also have very large tipping fees as disincentive for careless waste dumping. In countries like the Netherlands, for example, with a 90% reuse or recycling rate of their waste materials, they employ a tipping fee, a tax, and bans on materials that results in an average tipping fee cost of over $150 CAD/t (Saotome, 2007). Other European countries, like Sweden, Denmark, Germany, and Austria all have tipping fees roughly $150 CAN/t, and some even as high as $240 CAN/t in Luxembourg (Saotome, 2007).

Increasing tipping fees at C&D processing sites would be considered an advanced recommendation depending on the management program in place at the time of consideration. In concert with other management tactics, an increase in the cost of tipping fees would act as a substantial disincentive for waste producers in the province/municipality, and add a strong notion of stewardship at various levels of industry.

Wood Ban: The outright ban of wood from landfills has been discussed as a possibility within the province (Consultation Notes, 2013). Given the current solution within the HRM to chip most wood in to being topfill, biofuel, or animal bedding, banning wood would not seem to have much of an effect on the system in place. One of the more likely practical solutions to a wood ban might be the banning of certain sizes of wood. Metro Vancouver, for example, has a ban on clean or treated wood that exceeds 2.5 m in length (Metro Vancouver, 2013). As opposed to an outright ban on wood, developing a length specification on wood that cannot be landfilled might avoid useful wood being disposed of, but also incentivize sorting on work sites so that larger pieces of material can then be diverted towards reuse markets.

Industrial Symbiosis in Action

Nova Scotia Habitat for Humanity and the Dartmouth ReStore

The Nova Scotia Habitat for Humanity manages yearly projects to provide safe, cost effective, and quality homes for families in Nova Scotia. As a result of this project, the Habitat for Humanity ReStore staff is pursuing TDA and reused/recycled material use in their 2014 home build project. The Dartmouth ReStore is also very motivated to take part in a waste material Pilot through the municipality, and would like to pursue this opportunity following this report (Consultation Notes, 2013).

(Habitat for Humanity, 2013)

Black Business Initiative Halifax

The Black Business Initiative (BBI) is an initiative committed to growing a Black presence in a diverse range of business sectors including high-tech, manufacturing, tourism, and the cultural sector (BBI, 2012). With a large part of their member base currently involved as owners, operators, or contractors within the construction industry, BBI has a strong desire to pursue sustainable construction practices in its endeavors (Consultation Notes, 2013).

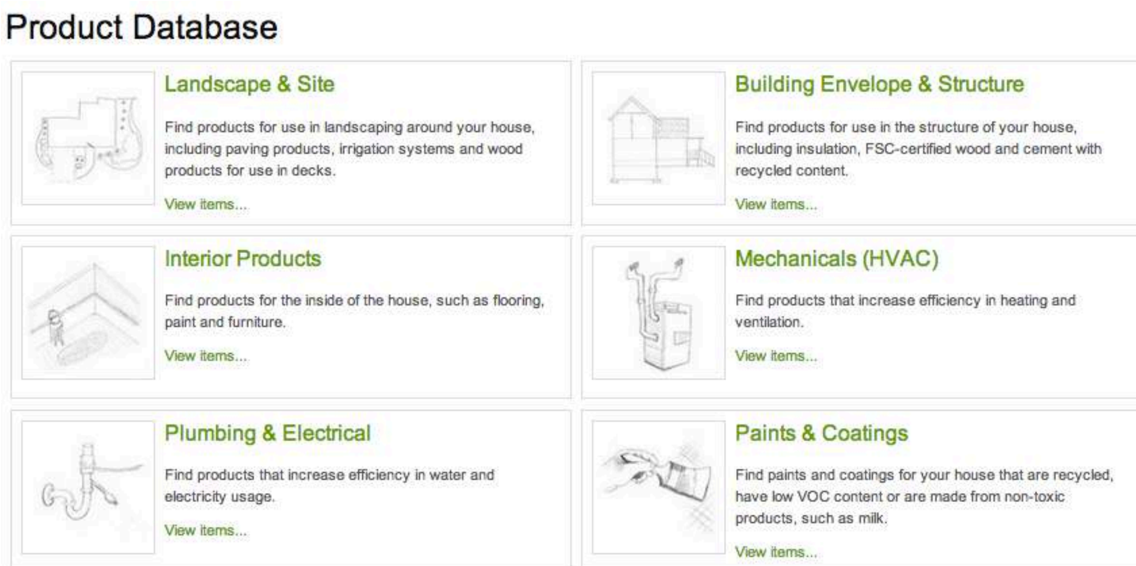
As a result of this project, the Black Business Initiative Halifax is pursing TDA use as road bed insulation and foundation infill on the construction of their first EnerGuide subdivision in Nova Scotia (Consultation Notes, 2013).

(BBI, 2012)

Canadian Green Building Council Atlantic Sustainable Materials Database

Through the Nova Scotia Youth Conservation Corp, ThermalWise (based in Halifax), developed a Sustainable Materials Database to serve as a resource for homeowners, building owners, and industry professionals in Atlantic Canada who are interested in energy efficiency and green building (Atlantic Green Building, 2013). Among the green project case studies and service database is a very comprehensive product database for sustainable building materials that can be found locally in every Atlantic province. The Canadian Green Building Council Atlantic (CaGBC Atlantic) is currently amalgamating this useful database with their website to offer this information to a larger demographic of building professionals.

As a result of this project, Tire Derived Aggregate has been added to the Infill/Backfill, Landscaping, Septic System, and Geothermal System sections of the database, and should be featured at a later date in 2014.



(Atlantic Green Building, 2013)

Conclusion

If nothing else, this report has revealed that the success of any type of used building material market depends on the adoption of a variety of sectors, industries, and stakeholders. As with any waste management framework, there is not one simple answer to how the HRM and Nova Scotia can manage its waste in residential construction practices alone, however, there exists a significant amount of promise for this development in the region.

Since residential construction has the potential to safely and inexpensively consume large amounts of waste material that are otherwise considered “troublesome”, it seems only logical that programs, systems, and policies should be put in place to capture what material is useful before less desirable waste management options are considered.

As landfills expand, populations grow, resources dwindle, and the residential environment becomes the focus of resource consumption and waste production, more and more jurisdictions will have to capitalize on waste materials to provide safe, affordable, efficient, and environmentally conscious housing. Because resources are still perceived to be abundant in North America, reusing waste material in residential construction is often considered alternative. Whether this perception changes in the coming years or not, capitalizing on waste materials in sustainable construction practices has consistently provided economic, social, and environmental advantages. For this reason, the HRM and Nova Scotia as a whole have a unique opportunity to capitalize on this emerging market to become stewards of a more sustainable built environment.

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Appendix A

Figure 1: The Waste Management Hierarchy (EPA, 2013)

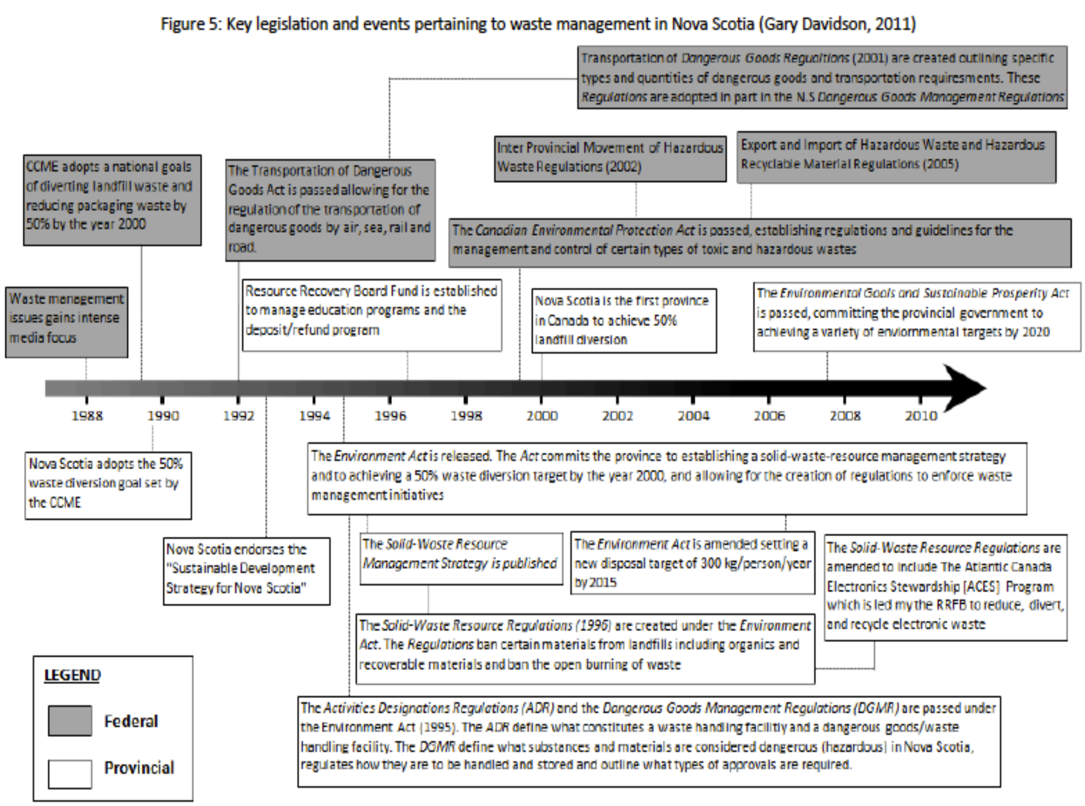

Figure 2: Nova Scotia Environmental Policy Development 1988-2010 (Davidson, 2011)

	Metric Tonnes	Metric Tonnes
Tonnages	**ICI**	**Residential**
Colchester	15,103	6,810
Cumberland	4,249	5,494
Guysborough	39,120	28,095
Kaizer Meadow	16,780	17,991
Otter Lake	84,573	55,987
Queens	9,426	9,858
West Hants	6,397	6,762
Total	**175,648**	**130,997**

Figure 3: Nova Scotia Waste Audit Data (RRFB, 2013)

Asphalt/Brick/Concrete	**$10.00/tonne**
Asphalt/Brick/Concrete	**$10.00/tonne**
Concrete With Rebar **(No Extruding Metal)**	**$25.00/tonne**
(With Extruding Metal) **Mesh or Rebar**	**$50.00/tonne**
Clean Asphalt Shingles **(tarpaper, nails)** **Clean wood, Brush, leaves, grass clippings**	**$75.00/tonne**
Other (Any One Item)	**$100.00/tonne**
Drywall, Ceiling tile, Vinyl, Plastic, Glass, Insulation, Styro Tar and gravel roofing, Painted wood:	**$100.00/tonne**
Mixed Loads (Any two items)	**$100.00/tonne**
Mixed Loads (Any two items) Containing carpet or inert material not considered construction or building materials	**$115.00/tonne**
Minimum Charge	**$10.00**

***Loads which contain carpet, burnt material, commercial or industrial waste, household waste, office waste or furniture will be charged at landfill rates ($115.00/tonne). We will not accept any food waste, hazardous or liquid materials or pressurized tanks. Surcharges will apply on non-compliance items.**

Figure 4: Halifax C&D Recycling Ltd. Tipping Fees (Halifax C&D Recycling, 2013)

Table 1

A Comparison of Methods for Reusing and Recycling C&D Waste in Europe and North America with Reference to their Implementation in the Halifax Regional Municipality

Materials	Reuse	HRM *	Recycle	HRM *
Whole structures	- Occasionally moved for reuse	√		
Aggregates	- Deconstructed brick-work can often be reused	0	- Aggregates commonly recycled into fill for roads and buildings - Recycled concrete used as aggregate in production of new concrete	√ x
Asphalt Shingles	- Research ongoing	0	- Used in asphalt pavement and other road construction applications - Used as a fuel	√ √
Clean Wood	- Architectural woodwork, heavy timbers and flooring often valued for reuse	√	Used as… - fuel - mulch - compost additive - Limited possibilities in manufacturing	√ x
Contaminated Wood	- Short life-span limits the potential for this	0	- Limited use as fuel - Research into composting ongoing	√ √
Treated Wood	- Potential for reuse due to long life-span	0	- Research currently being conducted	x
Gypsum Board	- Undamaged gypsum board can often be reused	0	Can be used… - In production of new gypsum board or cement - As a soil amendment	√ x
Metals	Structural steel and aluminum products can be reused if dismantled properly	0	Most metal waste is valued as a versatile recycled material - Metal waste is often the first material targeted for recycling on construction and demolition projects	√
Plastics	PVC window and door frames as well as gutters can be easily reused	0	Recycling markets are being developed for PVC pipes, window frames & vinyl siding	x
Ceiling tiles	Can be reused	0	Can be recycled into new ceiling tiles	x
Synthetic carpeting	Undamaged carpeting can be reused	0	Synthetic carpeting can often be recycled for use in new carpet components and other synthetic products	√

* Implementation in HRM of the methods summarized is indicated in the following manner:
√ = method has been implemented to some extent, x = method has not been implemented, 0 = state of

Figure 5: Jeffrey HRM C&D Study (Jeffrey, 2011)

Figure 6: Animal bedding and waste wood in the HRM

Figure 7: Renovators Resource Retail Store (Renovators Resources, 2013)

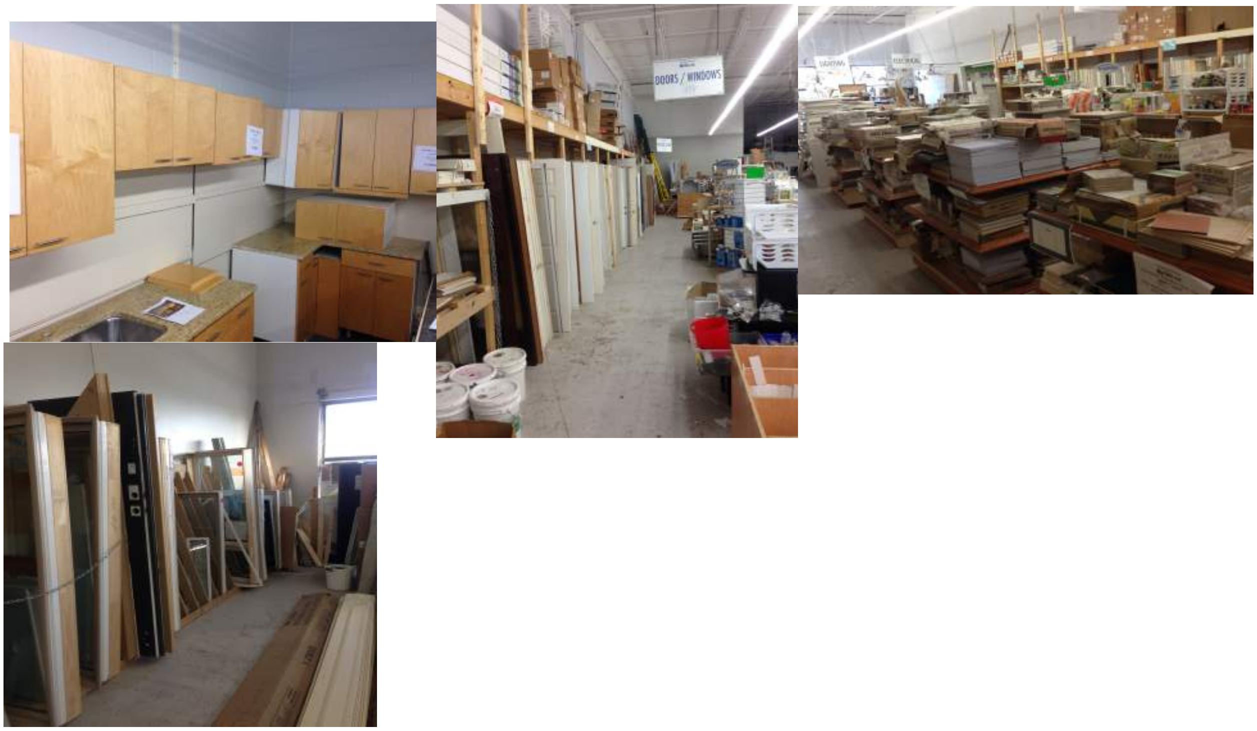

Figure 8: Dartmouth Habitat for Humanity ReStore

Figure 9: TDA storage piles in the HRM

Figure 10: 2012Architects recycled material home *Villa Welpeloo* (Szita, 2011)

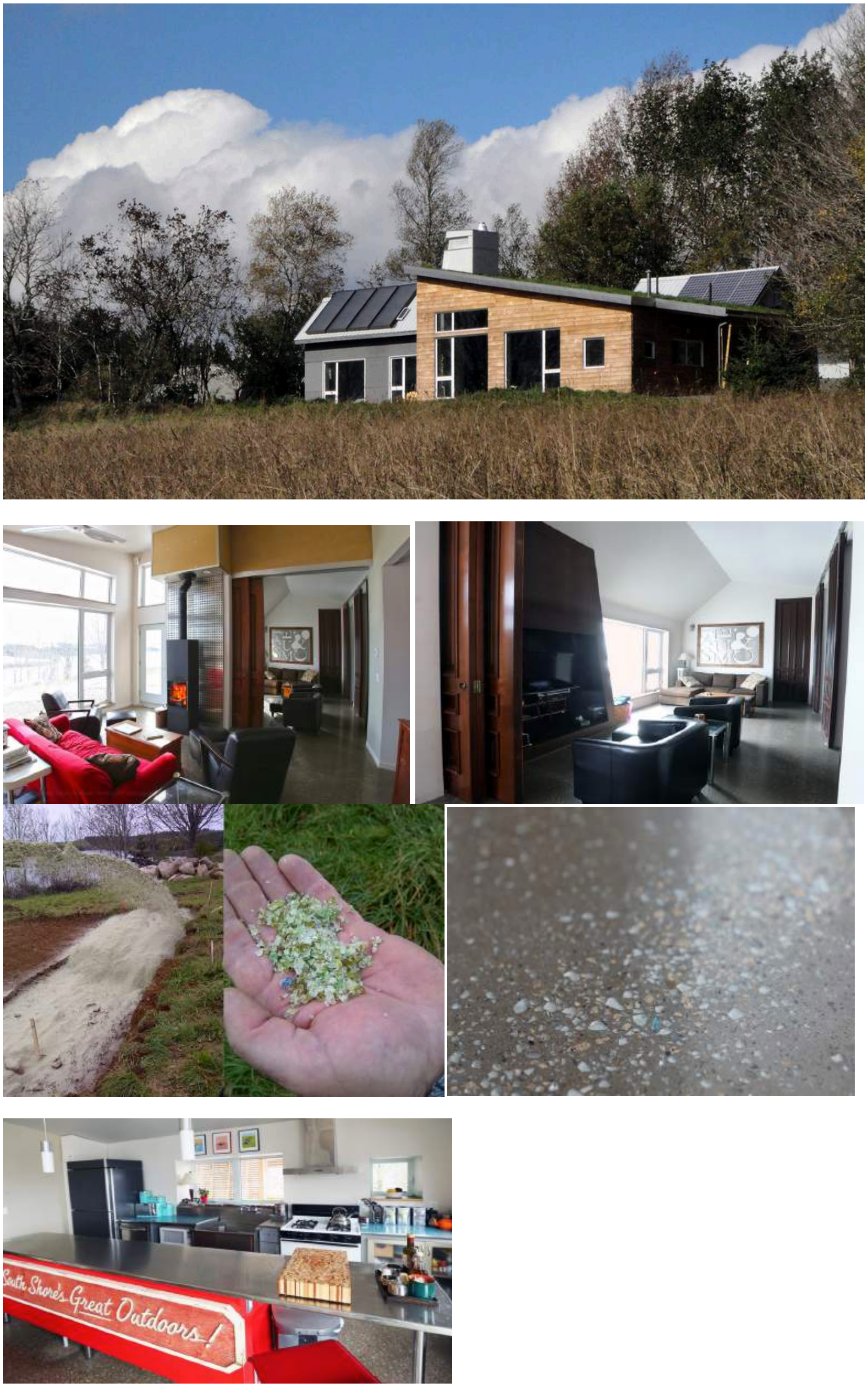

Figure 11: Solterre Design Concept House (Solterre, 2012)

Appendix B

Sample Consultation Session
A very brief presentation was made at the start of the consultation sessions to highlight how the project was developed, how it applies to MREM Studies, how it applies to RRFB research, and lastly to present a general statistical look at the wastes present in the HRM. Within the statistical look at wastes present in the HRM, a review of known attributes and uses for Tire Derived Aggregate (TDA) was presented, as well as some cutting edge examples of recycle and reused material construction.

The following questions are a compilation of the most common questions that would be asked to the variety of professionals that were consulted for the project. As the experience and expertise of each participant varied, these questions slightly differ depending on the participant. It can be assumed, however, that all questions followed the same themes outlined in the questions below, and conformed to the same ethical guidelines approved through Dalhousie University

1. Does your company/organization incorporate repurposed waste materials in its building designs? If yes, how?

2. Does your company/organization divert on-site waste materials? If yes, how?

3. Would your company/organization incorporate repurposed wood in its design if the quality of the products were maintained? Why or why not?

4. Before this presentation, had you ever heard of T.D.A. (Tire Derived Aggregate)?

5. Would your company/organization incorporate T.D.A. in place of other traditional products with similar uses in construction? Why or why not? If yes, in what capacities do you see it most useful?

6. In your opinion, what are the largest barriers to incorporating waste material in residential construction practices? How could this be remedied?

7. Do you have any ideas on how useful wood and other materials could be diverted towards repurposing in our jurisdiction?

8. Do you have any suggestions regarding this information session or project?

9. Would you be open to meeting or discussing via phone or email as this project progresses?

* The opportunity to discuss further with participants as the project progresses was asked as the potential for new ideas might be developed as more participants were consulted. The potential for additional feedback on different ideas is left open for this reason.

Canadian Green Building Council Atlantic Newsletter Article

This article appeared in the CaGBC Atlantic Newsletter in October of 2013 as recruitment for building professionals interested in contributing to the project through consultation sessions.

Repurposing: changing the way we look at waste materials

Closing the gap in waste management

Dalhousie University Masters student seeks your input

Davin St. Pierre, a Master's of Resource and Environmental Management student, is exploring the potential of diverting waste materials in the Halifax Regional Municipality towards sustainable construction.

Waste repurposing is the premise of this project. Having highlighted a few key gaps in how certain Construction and Demolition materials are processed and re-used, St. Pierre seeks to assess the potential of up-cycling our C&D wastes in to useful applications.

In conjunction with CaGBC Atlantic, Davin seeks the input of Members on the receptiveness or concerns surrounding the incorporation of repurposed material in construction, as well as ideas regarding potential diversion methods to reclaim targeted materials.

Results of this project will form recommendations through RRFB Nova Scotia on how we can foster industrial symbiosis among waste producers, waste managers, and construction/design professionals.

Interested in being a consultant for this project?

Your knowledge and opinion is needed, please get in touch!

davin.sp@dal.ca

If you have any questions
Please contact Davin St. Pierre at davin.sp@dal.ca

PUT WASTE IN ITS PLACE RRFB