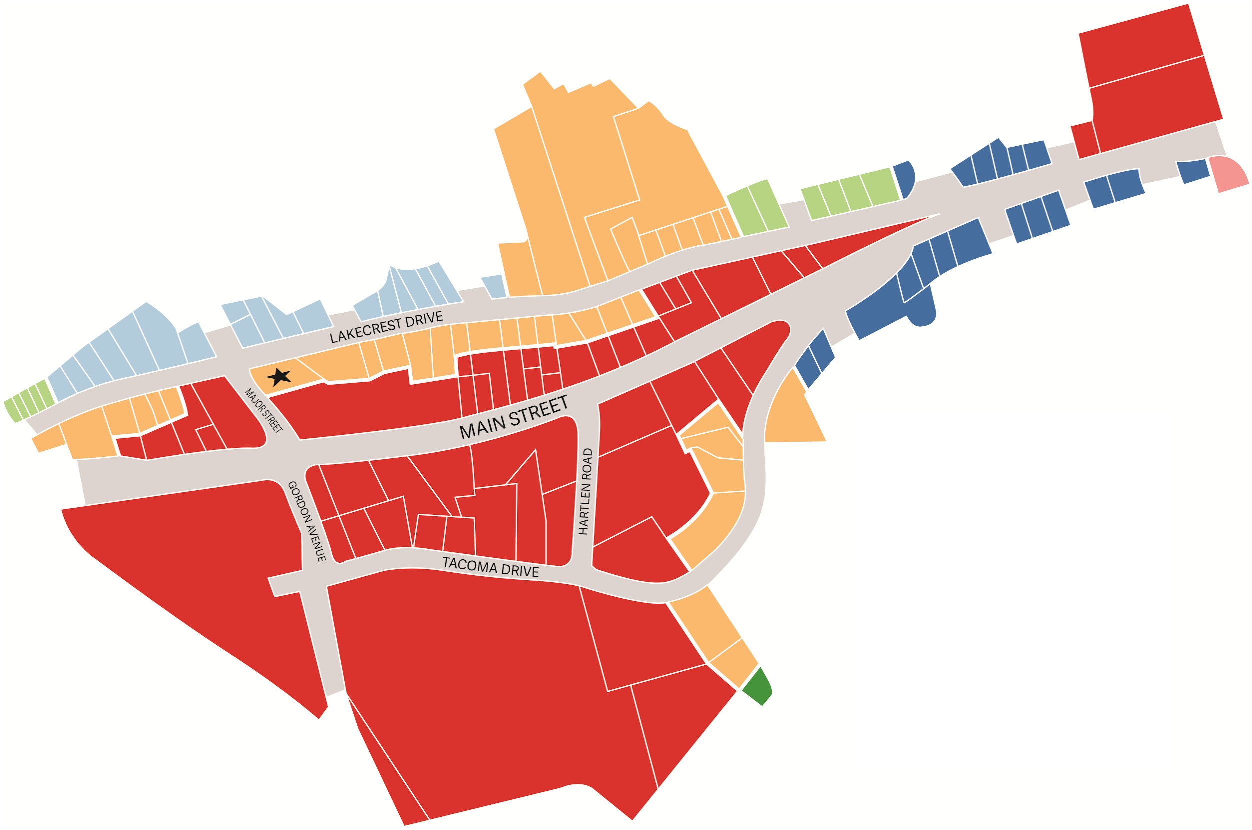

Village on Main: Transformation Toolkit Report

Stef Jutronich, Hillary Kretz, Stephen McIntosh & Duncan Tennant

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DALHOUSIE UNIVERSITY College of Sustainability

The Village on Main

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Executive Summary

Up-front costs and return on investment are important factors for developers and investors. Short-term thinking does not necessarily allow buildings to reflect or meet environmental standards and community desires. The Village on Main (VoM) Business Improvement District (BID), and its residents envision a village atmosphere that is accessible, safe, and vibrant. A “complete community” design meets these needs by providing health services, affordable housing, employment, schools, shops, and parks all within walking distance. Complete community design is the answer to the urban sprawl phenomenon that has been degrading our health and the environment since the 1960s.

Complete community design calls for infrastructure that is sustainable, affordable and enjoyable for all of its residents. The Transformation Toolkit is a user-friendly review of best development practices. The most cost-effective and environmentally responsible options have top priority. The Toolkit places the community as the prime stakeholder for building development, as they will live around and inside it. The investors and developers have a high stake in development, and a major priority has been given to them as well in deciding which practice to incorporate. The Toolkit corrects an assumption often held by developers, that building sustainably is prohibitively expensive. It includes a literature review, a model building exemplifying best practices, a pro forma cost analysis for the model building, a pamphlet which highlights the findings from the previous three sections, and an informational PDF to be attached to the already-established interactive webpage on the VoM BID’s website. Face-to-face interviews were conducted to gather expertise regarding social needs and cost of implementation. Architects, planners, and contacts with heating, ventilation, air conditioning (HVAC) expertise offered a variety of building perspectives, and altogether emphasized the importance of demonstrating cost-effective designs. An in-depth literature review provided understanding of the field as a whole - the accepted knowledge and controversies regarding green material selection, lighting, building foundation, HVAC, and water efficiency.

Introduction

The Main Street Area in Dartmouth, Nova Scotia, was developed as a commercial hub throughout the 1960s. Those developments assumed the kilometre-long area would become a destination for surrounding suburban residents. Halifax Regional Municipality (HRM) expects the municipality's population to rise by 73,115 people by 2031. Much of that new population is expected to reside in the urban centres. This is in part due to the newly-accepted policies outlined in Halifax's Centre Plan, which emphasizes urban densification, and moves away from continuing urban sprawl policies. Evidence shows that suburban living, a design that prompts enormous reliance on personal vehicles for transport, is not sustainable. Suburban sprawl does not conserve resources, protect the environment or facilitate efficient infrastructure.

Greg Fong and Graziella Grbac of the VoM BID are spearheading a visionary change for the Main Street area. They recognize that millennials want to live in walkable, complete communities, and that the growing senior demographic who use the many service centres on Main Street would benefit from living closer to the services they need. All signs indicate that Main Street, with higher residency, could thrive again as a village center.

Sustainable design is a component of creating complete communities. When design complies with core principles of social, economic, and ecological sustainability, the communities in which these designs are implemented inherently absorb these benefits. Sustainable design connects people with a natural landscape, while using renewable resources and minimally impacting local and global ecology. Sustainable design that integrates energy conservation mechanisms and aesthetically-pleasing building materials accomplish a major step towards transforming Main Street. The VoM seeks to raise awareness about these transformative development opportunities. This Toolkit offers a brief review of the best practices developers can use to develop Main Street in a forward-thinking and sustainable manner.

Methods

Both academic and non-academic sources were studied to determine sustainable development best practices. Reviewing the literature provided us with cutting edge research in sustainable development. It gave us a deeper understanding of the field as a whole and its controversies, and gaps in knowledge. In addition, we conducted face-to-face interviews with the following individuals to gather first-hand wisdom unavailable in scientific papers:

1) Rochelle Owen, Executive Director of the Office of Sustainability at Dalhousie University. Rochelle fulfilled the role of a developer in the development of various LEED-certified Dalhousie University buildings.

2) Peter Connell, Managing Director of the DSRA Architecture, Halifax, Nova Scotia. The architectural firm designed Dalhousie's LeMarchant building, combining their expertise with the University's LEED Gold targets.

3) Jeff DeCoste & Mitchell Keans: Specialists in heating, ventilation and air conditioning (HVAC). These specialists discussed indoor environmental comfort with our group.

4) Molly Fredeen, Masters of Environmental Studies Candidate and a Teacher's Assistant for Dalhousie's College of Sustainability Capstone class. Molly has work experience within the VoM BID and provided the group with frequent direction in the creation of the Transformation Toolkit.

5) Andrew Scanlan Dickie, Masters of Planning student at Dalhousie University. Andrew has work experience within the VoM BID and was particularly helpful in providing direction for the pro forma and the interactive webpage that will be added to the VoM's website.

After compiling the research into a best-practices report, it was determined that the best means of conveying the findings was in the form of a Transformation Toolkit. The Transformation Toolkit is comprised of several elements which present the findings of this report in different forms. These deliverables are explained in greater detail in the following "Deliverable" section.

Deliverable

The final deliverable to the Village on Main is called the *Transformation Toolkit*. The *Transformation Toolkit* is an amalgamation of three elements which inform developers about sustainable design practices. This report outlines the research that comprises a best practices review. Together, different facets of the project and complement each other. To condense the contents of this report into a tangible form, a pro forma cost analysis, an informational pamphlet, and a PDF page have been created.

Model Building

To demonstrate the potential benefits of implementing the practices, technologies, and materials outlined in this report, a model building which integrates all of these features was conceptualized. This building is the basis for the pro forma, the pamphlet, and the adjunct PDF for the interactive webpage. The model building complies with the existing parameters for developing in the VoM area and can serve as a practical example of sustainable development to inform future development.

Pro Forma (Appendix A)

A pro forma is a method by which financial aspects are calculated for a prospective project. For developers to adapt to sustainable building methods or practices, it is important to show a cost analysis of sustainable methods and materials. The pro forma showcases a cost and return through investment analysis by comparing a conventional building with a sustainable building. The pro forma will be available as a printed copy, as well as an excel file so the VoM BID and developers can personalize costs and inputs.

Pamphlet (Appendix B)

The pamphlet is to show prospective developers the key findings of our research in an easy to follow format. The pamphlet synthesizes information from all of the previous sections of the Transformation Toolkit. Included in the pamphlet is a brief description of our research, a description of the model building, the key findings of the pro forma analysis, and informational cutaways which highlight design elements recommended in this report. The pamphlet acts as an informational marketing material for both developers and members of the public

Interactive Webpage

To accompany the pamphlet, an interactive PDF was created to reiterate the same information in a different media form. This PDF is to be included in the Village on Main's existing interactive developer's guide which is featured on their website. The interactive PDF will allow website users to explore sustainable development techniques in association with Dartmouth's land-use bylaws and architectural requirements.

Keys to Sustainable Design

Sustainable Materials

Today's developers and designers have more options than ever when choosing green materials. When more sustainable materials are used, greater opportunities for cost-benefit trade-offs become available. Green materials are:

1) Non-toxic
2) Renewable
3) Don't require a lot of energy and other resources to make, acquire or use
4) Have the appropriate physical properties for their function
5) Meet or surpass regulations/ building code standards
6) Have good end-of-life options

(Keeler & Vaidya, 2016)[1]

For each category of material selection, there are options that are both environmentally sound and cost-effective. Managing the above-listed considerations and ensuring that materials don't drive up costs necessitates a cost-benefit analysis help to understand trade-offs. Beyond cost benefits, the primary benefits of informed material selection include:

1) Civic leadership
2) Community benefit
3) Occupant health and safety
4) Operational efficiency
5) Environmental performance
6) Meeting funding and regulatory requirements
7) Business and marketing opportunities and competitive edge

(Olubunmi, Skitmore & Xia, 2016)[2]

Green building incentives are critical in the promotion of green designs, however material selection in the design process can be a confusing and daunting task. Below, the "Tools for Green Market Selection" section explains how developers and planners alike can use certain tools to help guide the material selection process.

[1] Keeler, M., & Vaidya, P. (2016). *Fundamentals of integrated design for sustainable building.* https://books.google.ca/books?hl=en&lr=&id=SQglCgAAQBAJ&oi=fnd&pg=PR15&dq=sustainable+building+materials&ots=mYzhcHcUaE&sig=

[2] Olubunmi, O. A., Xia, P. B., & Skitmore, M. (2016). *Green building incentives: A review.*

Regulations and Accreditation Systems

Regulations for building materials informs early design decisions and material selection. Third party accreditation organizations, such as the LEED Green Building Rating System or BOMA BEST's Certification Program, offer credit points for meeting sustainable design criteria. Acquiring third-party certification from internationally-recognized standard organizations narrows the scope of material sourcing options and simplifies the process. The Forestry Stewardship Council (FSC) of Canada has a "marketplace" which provides local, green sourcing of wood that is also LEED approved. Using local sources contributes to the local economy and helps reach construction sustainability goals.

Reduce, Reuse, and Recycle Locally

Using reduce, reuse and recycle principles as a tool to guide the material selection process helps developers to meet consumer demand for environmentally responsibility whilst creating efficient buildings.

- Reduce the need to buy new products that are environmentally unsound to acquire and use
- Reuse materials such as wood floors, windows and doors from previous builds
- Recycle materials such as reclaimed lumber, recycled plastic, glass and tile.
- Source locally produced building materials to shorten transportation distances.

These choices cut transportation costs and reduce air pollution which are two important factors that should be considered. While locally produced materials are often better suited to local climatic conditions, availability of these resources are not always certain. Materials should be imported selectively if need be, and in small volumes where possible. For instance, the use of marble as a decorative material is not necessarily efficient as it must be hauled from far parts of the world. Steel, however, while also generally manufactured far from building sites, is suitable for building when considering its structural durability and strength. In many cases, there are cost savings associated with green building materials. For example, using Bubbledeck concrete foundation cuts construction costs by 10%, as shown in the "Foundations" section in this report.

The Market

Meeting consumer demand is an obvious but critical tool to material selection. Health Canada and The US Environmental Protection Agency (USEPA) report that North Americans spend about 90% of their time indoors. The USEPA also presents findings of indoor pollutant concentrations at levels two to five times higher than typical outdoor levels. Furthermore, there is an increasing body of scientific evidence that suggests that the air in buildings and homes can be more seriously compromised than the outdoor air, even in the largest and most industrialized cities.[3] Fatigue, dizziness, headaches, heart disease, cancer and respiratory ailments have all been linked to indoor air quality.[4]

A growing health and wellness culture demands that environmental health becomes a fundamental decision-making factor in development and construction. Material quality and a great indoor environment have been brought to the forefront of design dialogues. There are various sources of indoor air pollution and a growing body of scientific evidence suggests that the materials used to make buildings are at the forefront of the problem. Non-toxic material selection is thus critical in the design process. Whenever possible, choosing natural, eco-friendly building materials from reputable and trusted suppliers helps to achieve superior indoor air quality.

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3 United States Environmental Protection Agency. (2017). The Inside Story: A Guide to Indoor Air Quality. https://www.epa.gov/indoor-air-quality-iaq/inside-story-guide-indoor-air-quality

4 United States Environmental Protection Agency. (2017). The Inside Story: A Guide to Indoor Air Quality.

Materials, Technologies, and Practices

Building Foundations

Using sustainable building processes and materials can be done on large scale items such as the structural beams, and the very foundation of the building. When choosing a building's flooring foundation, there are few environmentally friendly options as the common concrete foundation is the simple, cheap solution. The carbon footprint of concrete is typically one of the most environmentally damaging parts of construction of a building.

There are two prominent solutions in the market for environmentally friendly concrete. Firstly, there is the Bubbledeck technology, and secondly there is a concrete company called CarbonCure. Bubbledeck uses hollow balls to fill most of the area, two sides of wire reinforcement and then pours concrete around the balls.[5] Bubbledeck produces floors 20% faster with less framework and fewer beams. It reduces construction costs by 10%, and provides a 35% reduction in concrete usage.[6] Dalhousie University used Bubbledeck flooring in their Mona Campbell building on the Studley campus, and were one of the firsts to use the technology in North America.

CarbonCure is a retrofit technology that uses recycled carbon within their concrete. The technology fits with current common building practices, so there is no major change with using CarbonCure. It takes carbon dioxide from factories and injects it into the wet concrete while it's being mixed.[7] The amazing thing about both Bubbledeck and CarbonCure, is that they can both be used together, and still be cost effective.

Structural Beams

The primary goal of researching structural beams is to determine the most sustainable options for either wooden or steel beams. We found from speaking with Peter Connell that both options have near equivalent structural integrity. The decision of which material to use is often based on preference. This research focuses on the most sustainable material choices.

Much research has looked at environmental solutions for structural beams, there is little technology to improve what is already a fairly sustainable process. Both wooden and steel beams have their environmental upsides and downsides but the final choice is

[5] Bubbledeck. *Technology- Concept.* http://www.bubbledeck.com

[6] Alter, L. (2012, April 30). *Bubble Deck Technology Uses Less Concrete by Filing The Slab With Beach Balls*.http://www.treehugger.com/green-architecture/bubble-deck-technology-uses-less-concrete-filing-slab-beach-balls.html

[7] Carbon Cure. (2017). *CarbonCure Transforming the Space we Live in.* http://carboncure.com/

often related to the architect's preference of design. A wooden beam is a nice aesthetic touch in a building, is lighter, and can reduce concrete usage. However, it doesn't last as long as steel and at times can only hold a certain amount of weight. The environmental benefits of using wood in building construction are very high. Wood is cheaper, uses fewer fossil fuels to extract and use, stores carbon, is a natural insulator and can be recycled. LEED recognizes various wood retailers who are held to a certain level of responsibility through the Certified Forestry Stewardship Council (CFSC).

The CFSC is a marketplace to find local timber either recycled or extracted ethically and responsibly.[8] Steel, on the other hand, is more structurally sound and in some cases beams can be produced using 100% recycled material, it also lasts longer. It is easy to take down and recycle when old buildings are torn down, and what cannot be retrofitted can be used as scrap to create new steel.[9] Steel beams lasting longer can contribute to a smaller ecological footprint by the non-necessity of reconstruction, and reduction of all construction carbon outputs due to less reconstruction. When all is considered, wood and steel beam infrastructure are fairly even in terms of environmental benefits and recyclability.

Lighting

40% of energy use worldwide comes from buildings.[10] Often, electricity use drives enormous environmental impacts. Energy-efficient lighting is an important step in designing energy-efficient buildings. Daylighting, efficient lights and good controls reduce energy demands and research has proven that good lighting makes people happier and more productive.[11]

Daylighting

Daylighting is the controlled admission of direct sunlight, natural light and diffused-skylight into a building to reduce the use of electric lighting and to save energy. Daylighting requires an integrated design approach since it involves decisions about building form, climate, siting, windows, lighting controls and lighting design criteria. It is best to incorporate daylighting decisions in new construction projects, rather than retrofits. Automated electric lighting controls that are daylight-responsive are absolutely

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[8] Forest Stewardship Council. *Forest Stewardship Council Marketplace.* https://marketplace.fsc.org/results?searchtext=&product_level1=&species=&fsc_recycled=on&industry=&country=&postalCode=b https://ca.fsc.org/en-ca

[9] Sustainable in Steel. (2017). http://www.sustainableinsteel.eu/

[10] Ahmad, A. S., Hassan, M. Y., Abdullah, M. P., Rahman, H. A., Hussin, F., Abdullah, H., & Saidur, R. (2014). A review on applications of ANN and SVM for building electrical energy consumption forecasting. http://www.sciencedirect.com/science/article/pii/S1364032114000914

[11] Ahmad, A. S., Hassan, M. Y., Abdullah, M. P., Rahman, H. A., Hussin, F., Abdullah, H., & Saidur, R. (2014). A review on applications of ANN and SVM for building electrical energy consumption forecasting. http://www.sciencedirect.com/science/article/pii/S1364032114000914

essential in any daylighting design due to their energy saving abilities. Daylighting design saves energy with electric lights that are turned off or dimmed when there is sufficient daylight illumination. Daylight-responsive dimming technology is comprised of motion-detecting sensors to detect occupancy, as well as photocells in the light fixture that sense the availability of light and dim or turn off electric lighting accordingly. Dalhousie's Mona Campbell building is a LEED Gold accredited building that uses such lighting strategies. As stated on Dalhousie's Office of Sustainability webpage, "All lighting in the building is modeled at being 57% better than the national model energy code. This is achieved through efficient lighting fixture placement, the use of high efficiency T8s, exterior LED canopy lighting, maximizing natural light, and lighting controls."[12]

Daylighting has traditionally been more popular in commercial office buildings and schools, but demand in residential buildings is growing given its practicality and cost savings. Daylighting offers immense potential in energy cost reduction. For example, an estimated initial cost increase of $0.50 to $0.75 per square foot of space for dimmable fixtures, ballasts, and controls has been shown to save between $0.05 to $0.20 per square foot annually.[13] Additionally, electric lighting adds to the loads imposed on a building's mechanical heating and cooling equipment. Reducing electric lighting with daylight dimming technologies can reduce heating and cooling energy costs by an additional 10% to 20%.[14]

Compact Fluorescent Bulbs (CFLs) and Light Emitting Diodes (LED)

Compact Fluorescent Lights (CFLs) are the most popular energy efficient bulbs currently available. This type of bulb consumes an average of 75% less electricity than conventional incandescent lights and reduces the overall electricity demand, which in turn reduce the greenhouse gas emissions associated with fossil-fuel power plants.[15] Light Emitting Diode (LED) bulbs are more expensive to purchase, but last longer and promise even greater electricity savings. They also avoid some of the issues posed by CFLs such as disposal, and mercury content.[16]

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[12] Mona Campbell Building. https://www.dal.ca/dept/sustainability/programs/Built_Environment/New_Construction/Mona_Campbell.html

[13] National Institute of Building Science. https://www.wbdg.org/resources/daylighting

[14] National Institute of Building Science. https://www.wbdg.org/resources/daylighting

[15] Energy Efficient Lighting. http://www.davidsuzuki.org/what-you-can-do/climate-change/science/energy/energy-efficient-lighting/

[16] Energy Efficient Lighting. http://www.davidsuzuki.org/what-you-can-do/climate-change/science/energy/energy-efficient-lighting/

Heating, Ventilation and Air Conditioning

Older buildings often leak heat, which leads to a higher ecological footprint and unnecessarily higher energy bills. A building envelope is everything that separates the inside of a building from the outside, including walls, floors, fenestrations, doors, and the roof. These components play a major part in controlling temperature and humidity. A perforated building envelope will unnecessarily leak heat, and thermal bridges (parts of a building with higher heat transfer than surroundings) will reduce overall insulation. Windows are also often a major culprit for this type of leak.

Many of the inefficiencies related to heating can be addressed with the standards developed by the Passivhaus Institute. Meeting the efficiency standards of Passivhaus can drop heating by as much as 90%.[17] These results are achieved by employing a combination of techniques.

- Superinsulation, in the form of R-40 (very thick) insulation in the walls and R-60 insulation in the roof; triple-glazed south-facing windows
- A heat recovery ventilator (HRV), recovering intrinsic heat from light fixtures, appliances, and any other heat-radiating device, allow for a simple and minimal heat generating unit. The small amount of needed heat could be provided by solar heat generation. Many still choose, however, to include a small conventional heat generator.

At the heart of the Passivhaus standard are two requirements:

1. Every building must pass a blower-door test demonstrating exceptional airtightness. The Passivhaus airtightness standard is 0.6 AC/H (air changes per hour) at 50 Pa. The Canadian standard is less strict at 1.5 AC/H at 50 Pa.
2. Every building must consume no more than 15 kilowatt-hours of energy per square meter of floor area.

Superinsulation

A pillar of the Passivhaus standard is superinsulation. Compared to conventional building design, superinsulation requires much higher levels of insulation and airtightness. The walls generally rate around R-40, and the roof, R-60. Add to this insulation continuity where walls meet roof, airtight construction around leaky windows and doors, and designing out large windows, ideally allows for the structure to be

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[17] Passivhaus Institute. (2015). *Energy efficiency of the Passive House Standard: Expectations confirmed by measurements in practice.* http://passiv.de/downloads/05_energy_efficiency_of_the_passive_house_standard.pdf

predominantly heated by intrinsic heat sources and waste heat, such as light fixtures, white appliances, and the occupants. To this point, the human body emits heat equivalent to 100W of radiated thermal energy.

Williamsburg, New York, mixed-use Passivhaus apartment has superior heat retention compared to neighbours. [18]

Thermal Bridges

Thermal bridging occurs when an area of a building has a significantly higher heat transfer than the surrounding material. This reduces thermal insulation, and increases heating costs. Thermal bridges often occur in traditional building, due to oversight or lack of concern over heat loss. Ignoring thermal bridges has been shown to result in actual thermal losses up to 35%.[19] The bridging commonly occurs when concrete balconies extend the floor slab through the building envelope, or in the interface between window and wall.

Architects can mitigate thermal bridging by simply employing a continuous thermal barrier on the outside of highly conductive materials, or lap insulation to mitigate thermal bridging.

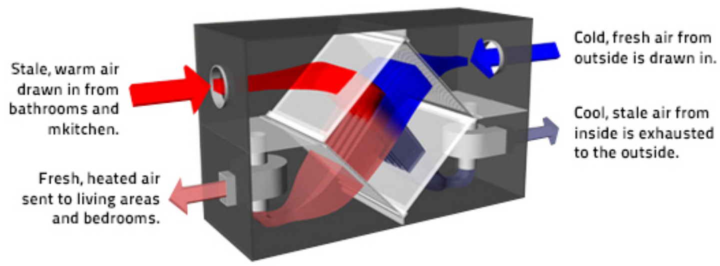
[18] Source: http://inhabitat.com/nyc/sneak-peak-first-look-inside-williamsburgs-newest-passive-house/174-grand-street-passive-house-12/

[19] Papadopolous, A.M., & Theodosiou, T.G., 2008. The impact of thermal bridges on the energy demand of buildings with double brick wall constructions. http://www.sciencedirect.com/science/article/pii/S0378778808001321

Energy Gain Windows

Triple-pane glazed windows had, until recently, been unavailable to the majority of Canadians. Now, they have more than 70% market penetration in Europe, and dropped in price significantly.[20] Similar trends are happening in Canada. These windows are requisite to meet the Passivhaus standard. They are manufactured with high R-values, and with a barrier in between the inside and outside window frames to prevent energy loss through thermal bridging.

How Heat Recovery Ventilators Work



Heat Recovery Ventilator

Fresh air is an important consideration when high airtight standards are observed.
A Heat Recovery Ventilator (HRV) employs high-efficiency electronically commutated motors (ECM) to circulate air between the structure and its environment.
Models appropriate to Passivhaus standards have a heat recovery rate between 60-80%.[21] The image shows this method of heat recovery and ventilation.

Water Efficiency

Water efficiency are reducing water wastage and reducing the long-term costs of water usage are two concentrations for buildings. The aforementioned concentrations can be achieved through the implementation of three general strategies.

- System optimization
- Water conservation
- Water reuse/recycling

(Bourg, J., 2016)[22]

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[20] Passipedia, 2016. *Are Passive Houses cost-effective?* https://passipedia.org/basics/affordability/investing_in_energy_efficiency/are_passive_houses_cost-effective

[21] Passipedia. *Types of Ventilation.* https://passipedia.org/planning/building_services/ventilation/basics/types_of_ventilation#the_convenient_solutionsupply_and_exhaust_air_systems_with_heat_recovery

[22] Bourg, J., 2016. *Whole Building Design Guide.* https://www.wbdg.org/resources/water-conservation.

Water Efficient Plumbing Fixtures

Residential water usage can be reduced by approximately 55% by installing off the shelf efficiency fixtures such as faucets, appliances, and toilets. Efficient taps and shower heads utilize flow limiters as well as aerators which mix airflow into the water streams. These taps and shower heads can save as much as 19 litres per minute, resulting in average water savings of approximately 14,500 litres each.[23] Efficient appliances can be an easy place to start for water savings. Water efficient clothes washers and dishwashers can reduce water usage by as much as 65% and 50% respectively when compared to conventional models.[24]

Efficient Toilets

Toilets are a main source of water use within a household, accounting for approximately 30% of water-usage.[25] Older conventional toilets can use as much as 6 gallons per flush, while "low-flow" models use as little as 1.28 gallons, saving over 2/3 of the water (WaterSense, n.d.). Replacing old models with efficient versions saves an average of 13,000 gallons per household per year.[26]

Irrigation and Landscape Measures

Depending on location, water usage for landscaping purposes can often account for upwards of 20% of facility water consumption.[27] This makes landscaping an important area to focus on for water efficiency. Planning for efficient landscape water-use in a new facility consists of three primary aims:

- Reduce the amount of turf and other irrigated areas
- Ensure water-efficient design of irrigation systems
- Specify native plantings or climate-appropriate landscape materials (Xeriscape)

(Bourg, J., 2016)[28]

On the most basic level, irrigation costs can be reduced by limiting the area which needs to be irrigated, though this option may not be particularly appealing as in essence it advocates for reducing greenspace. Aside from limiting irrigated areas, system optimization can also be utilized. Ensuring that sprinklers aren't watering non-essential areas, avoiding over watering, and monitoring for leakage are ways that systems can be

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[23] Government of Australia. *Water-efficient appliances and toilets.* http://yourenergysavings.gov.au/information/water-efficient-appliances-fixtures
[24] Government of Australia. *Water-efficient appliances and toilets.* http://yourenergysavings.gov.au/information/water-efficient-appliances-fixtures
[25] WaterSense. *Water-Efficient Toilets.* https://www3.epa.gov/watersense/products/toilets.html
[26] WaterSense. *Water-Efficient Toilets.* https://www3.epa.gov/watersense/products/toilets.html
[27] Bourg, J., 2016. *Whole Building Design Guide.* https://www.wbdg.org/resources/water-conservation.
[28] Bourg, J., 2016. *Whole Building Design Guide.* https://www.wbdg.org/resources/water-conservation.

designed for water savings. Additionally, the practice of xeriscaping can be applied which limits the need for irrigation by making sure plants are either native or climate appropriate. These plants are less likely to require maintenance and irrigation than non-regional or climate adverse plants.

Water Recycling/Reuse

A great deal of water that passes through and around a building can be recycled for other purposes within the building. Rain water from outside of the building can also be captured and used for these tasks.

A green roof can be an effective method of capturing and filtering rainwater, as well as serving a number of other purposes. The cost of installing a green roof typically ranges between $6-$21/sq.ft. depending on availability of resources, size and complexity of project, and other external factors.[29] Benefits of green roofs include:

- Control storm water runoff
- Improve water quality
- Reduce urban heat island effect
- Improve air quality
- Reduce heating/cooling costs
- Extend life span of roof membrane
- Provide amenity, improved views

(Barron, M. 2006)[30]

Water that has previously been used within the building, known as greywater, can be reused for non-potable purposes such as landscaping, toilet flushing, HVAC and more. Greywater can be piped from showers, filtered, and fed back into building systems.[31]

Rainwater capture can also be utilized to decrease demand on conventional water sources. Toilet flushing, laundry washing, and irrigation can make use of rainwater which would otherwise be wasted. Typically rainwater collection can replace as much as 1/3 of the water supplied.[32]

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[29] Toronto and Region Conservation, 2007. *An economic analysis of green roofs.* http://www.sustainabletechnologies.ca/wp/wp-content/uploads/2013/03/GR_Econ.pdf

[30] Barron, M., 2006. *Green Roofs*. http://search.proquest.com.ezproxy.library.dal.ca/docview/230112497/abstract/F63E856571B34927PQ/1?accountid=10406

[31] City of Guelph. *Greywater reuse system.* http://guelph.ca/living/environment/water/water-conservation/greywater-reuse-system/

[32] Rygaard, M., Binning, P. J., Albrechtsen, H., 2011. *Increasing urban water self-sufficiency: New era, new challenges* http://www.sciencedirect.com.ezproxy.library.dal.ca/science/article/pii/S030147971000294X

Conclusion

There are many ways that buildings can be designed and built for reduced environmental impacts. This report advocates the utilization and sourcing of materials with smaller ecological footprints, the use of resource efficient fixtures, and overall efficient building design. To fulfill these goals, it is recommended that the following considerations be made: minimize the environmental footprint for structural elements such as beams and foundations; optimize HVAC systems within the building; enhance the building envelope for maximum temperature retention; utilize energy and water efficient fixtures and design elements. By implementing any number of these strategies, strides can be made to improve adherence to the principles of sustainable design and thereby, as shown in the pro forma, increase the return on investment.

To further convey the information included within this report we have included a model building scenario, a pro forma analysis, a pamphlet, and a PDF web page. We hope this assist VOM with the primary aim of the Transformation Toolkit, which is to offer information and real world resources to assist the Village on Main to promote sustainable development within its region.

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Appendix A

Transformation Toolkit Building Practices, Medium Quality Building

* Changes have been highlighted by altering the font colour to light green

All sources of data that differ from the previous sheet are cited in the Report named "Transformation Toolkit".

Description

Description	
Project Type	Mixed Use
No. Commercial Floors	1
Takeout Plan	10 years
No. Residential Floors	4
Underground parking?	Yes
Location	67 Tacoma Drive
Site Area	28,210 ft2
Gross Liveable Area	80,000 ft2
Gross Building	130,000 ft2
Max height	80ft
Max sqft	225,680 ft2

Rentable

Residential	Quantity	Size (square feet)	$ Per SqFt	Monthly Rent Per Apt($)	Yearly Rent
Bachelor	20	500	$ 1.45	$ 725.00	$174,000
1 BDRM	16	700	$ 1.25	$ 875.00	$168,000
2 BDRM	20	900	$ 1.45	$ 1,305.00	$313,200
3BDRM	24	1700	$ 1.25	$ 2,125.00	$612,000
Total		80000			$ 1,267,200.00

Commercial				Monthly Rent	Yearly Rent
Retail	2	2000	$ 16.00	$ 5,333.33	$ 64,000.00
Retail2	1	2500	$ 18.00	$ 3,750.00	$ 45,000.00
Retail3	1	4000	$ 16.00	$ 5,333.33	$ 64,000.00
Retail4	1	2000	$ 18.00	$ 3,000.00	$ 36,000.00
Total		12500			$ 209,000.00

Other Revenues	Quantity	Size (feet)	$ Per SqFt	Price Per Space	Yearly Rent
Bike Parking	15	6X2		$12	$ 2,160.00
Parking Garage	102	9X18		$100	$10,200
Utilities Room	42	8x9	$ -	$ -	$ -
Art Exhibit Space1	1	500	$ 1.00	$ 500.00	$ 6,000.00
Art Exhibit Space2	1	800	$ 1.00	$ 800.00	$ 9,600.00
Revenues					$ 27,960.00

TOTAL YEARLY RENTABLE/REVENUE $ 1,504,160.00

Costs

Construction			
Type	Total Square Footage	$PSF	Cost
Residential	86,666.68	$ 160.00	$ 13,866,668.80
Enclosed Mall	21,666.67	$ 180.00	$ 3,900,000.60
Parking Garage	21,666.67	$ 100.00	$ 2,166,667.00
Dimmable Lights	86,666.68	$ 0.50	$ 43,333.34
Green roof	10,000.00	$15	$ 150,000.00
BubbleDeck Savings			$ 2,012,666.97
CarbonCure Savings			$ 100,633.35
Total			$ 18,013,369.42

Operating Costs		
Operating Costs & Taxes	30%	$ 451,248.00
Assuming Utilities are 30% of Operating Costs, and HVAC is 1/3 of all Utilities		
HVAC original	30% of 30%	$ 45,079.68
HVAC with TT practices	Less 80%	$ 4,057.17
HVAC savings		$ 41,022.50
Lighting Savings	$0.15 PSF	$ 13,000.00
Total Operating Costs and Taxes		$ 410,225.50
Landlord Misc Expenses	2%	$ 30,083.20
Vacancy Rate	4%	$ 60,166.40
Total		$ 500,475.10

Land	
Appraisal of Current land	$526,300
Tax Rate	$2.83
Current Property Taxes	$14,894

Total Costs Less Construction $ 515,369.39

TOTAL COSTS ############

Net Operating Income

Net Operating Income	
Costs	$ 515,369.39
Rentables+ Revenues	$ 1,504,160.00
Net Operating Income	$ 988,790.61

Re-Sale Price

Re-Sale Price	
Cap Rate	6%
Net Operating Income	$ 988,790.61
Re-sale Price	$16,479,843.57

Return On Investment

Return On Investment	
Purchase Price	$ 526,300.00
Construction costs	$ 18,013,369.42
Operating costs	$ 5,153,693.86
Taxes	$14,894
Re-Sale Price	$ 16,479,843.57
Rentables + Revenues	$ 15,041,600.00
ROI	$7,813,186.01

Breakeven Analysis

Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Costs	$ 18,513,844.51	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39
Rentables + Revenues	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00
Over/Under Amount	$ (17,009,684.51)	$ (16,020,893.90)	$ (15,032,103.28)	$ (14,043,312.67)	$ (13,054,522.06)	$ (12,065,731.44)	$ (11,076,940.83)	$ (10,088,150.21)	$ (9,099,359.60)	$ (8,110,568.98)

Year	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Construction Costs	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39	$ 515,369.39
Rentables + Revenues	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00	$ 1,504,160.00
Over/Under Amount	$ (7,121,778.37)	$ (6,132,987.75)	$ (5,144,197.14)	$ (4,155,406.53)	$ (3,166,615.91)	$ (2,177,825.30)	$ (1,189,034.68)	$ (200,244.07)	$ 788,546.55	$ 1,777,337.16

Conventional Building Practices, Medium Quality Building

All data sources come from the sheet labeled "Sources of Data", and the links will show you the following:
The CAP rate was derived from an analysis of the Cap rate's in all of Canada from CBRE's Q4 resulta from 2016.
The cost of construction was based off an Altus Group report of Canadian construction costs in 2015.
The lease prices of apartments were done based on an evaluation of current available apartments in the area off Kijiji.ca.
The Vacancy rate was derived from a report from Canada Mortgage and Housine Corporation.

Description

Description	
Project Type	Mixed Use
No. Commercial Floors	1
Takeout Plan	10 years
No. Residential Floors	4
Underground parking?	Yes
Location	67 Tacoma Drive
Site Area	28,210 ft2
Gross Liveable Area	80,000 ft2
Gross Building	130,000 ft2
Max height	80ft
Max sqft	225,680 ft2

Rentable

Residential	Quantity	Size (square feet)	$ Per SqFt	Monthly Rent Per Apt($)	Yearly Rent
Bachelor	20	500	$ 1.45	$ 725.00	$174,000
1 BDRM	16	700	$ 1.25	$ 875.00	$168,000
2 BDRM	20	900	$ 1.45	$ 1,305.00	$313,200
3BDRM	24	1700	$ 1.25	$ 2,125.00	$612,000
Total		80000			$ 1,267,200.00

Commercial				Monthly Rent	Yearly Rent
Retail	2	2000	$ 16.00	$ 5,333.33	$ 64,000.00
Retail2	1	2500	$ 18.00	$ 3,750.00	$ 45,000.00
Retail3	1	4000	$ 16.00	$ 5,333.33	$ 64,000.00
Retail4	1	2000	$ 18.00	$ 3,000.00	$ 36,000.00
Total		12500			$ 209,000.00

Other Revenues	Quantity	Size (feet)	$ Per SqFt	Price Per Space	Yearly Rent
Bike Parking	15	6X2		$12	$ 2,160.00
Parking Garage	102	9X18		$100	$ 10,200.00
Utilities Room	42	8x9	$ -	$ -	$ -
Revenues					$ 12,360.00

TOTAL YEARLY RENTABLE/REVENUE $ 1,488,560.00

Costs

Construction			
Type	Total Square Footag	$PSF	Cost
Residential	86666.68	$ 160.00	$ 13,866,668.80
Enclosed Mall	21666.67	$ 180.00	$ 3,900,000.60
Parking Garage	21666.67	$ 100.00	$ 2,166,667.00
Total			$ 19,933,336.40

Operating Costs		
Operating Costs & Taxes	30%	$ 446,568.00
Landlord Misc Expenses	2%	$ 29,771.20
Vacancy Rate	4%	$ 59,542.40
Total		$ 535,881.60

Land	
Appraisal of Current land	$ 526,300.00
Tax Rate	$ 2.83
Current Property Taxes	$14,894

Total Costs Less Construction $550,775.89

TOTAL COSTS $ 20,484,112.29

Net Operating Income

Net Operating Income	
Costs	$ 532,343.89
Rentables+ Revenues	$ 1,488,560.00
Net Operating Income	$ 956,216.11

Re-Sale Price

Re-Sale Price	
Cap Rate	6%
Net Operating Incor	$956,216.11
Re-sale Price	$15,936,935.17

Return On Investment

Return On Investment	
Purchase Price	$ 526,300.00
Construction costs	$ 19,933,336.40
Operating costs	$ 5,507,758.90
Taxes	$ 148,942.90
Re-Sale Price	$ 15,936,935.17
Rentables + Revenues	$ 14,885,600.00
ROI	$ 4,706,196.97

Breakeven Analysis

Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Costs	$ 20,484,112.29	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89
Rentables + Revenues	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00
Over/Under Amount	$ (18,995,552.29)	$ (18,057,768.18)	$ (17,119,984.07)	$ (16,182,199.96)	$ (15,244,415.85)	$ (14,306,631.74)	$ (13,368,847.63)	$ (12,431,063.52)	$ (11,493,279.41)	$ (10,555,495.30)

Year	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Construction Costs	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89	$550,775.89
Rentables + Revenues	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00	$ 1,488,560.00
Over/Under Amount	$ (9,617,711.19)	$ (8,679,927.08)	$ (7,742,142.97)	$ (6,804,358.86)	$ (5,866,574.75)	$ (4,928,790.64)	$ (3,991,006.53)	$ (3,053,222.42)	$ (2,115,438.31)	$ (1,177,654.20)

Appendix B

ABOUT

The Transformation Toolkit is the product of a user-friendly review of best development practices. The most cost-effective and environmentally responsible options have top priority.

OUR BUILDING

A Model Building was concieved as a means of demonstrating the benefits of integrating environmentally responsible materials and practices into development.

To this point, the toolkit corrects an assumption often held by developers: building sustainably is prohibitively expensive.

PRO FORMA

We performed a pro forma (a type of cost analysis for prospective projects) comparing the financial elements of building using conventional practices to building using the practices outlined in our Transformation Toolkit. We found that our building gave a substantially larger return on investment and offered a shorter break even period on the development.

Conventional: Return on Investment: $4,706,196.35
Break even period: +20 years

Sustainable : Return on Investment: $7,851,969.97
Break even period: 18 years

CHANGE IS GOOD. TRANSFORMATION IS BETTER.

Contact Information:

Main Street Dartmouth and Area Business Improvement Association (BID)

Suite 208-175 Main Street
Dartmouth, Nova Scotia, B2X 1S1

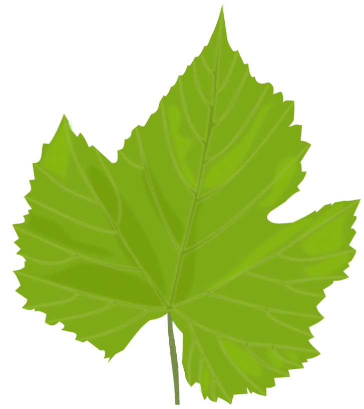
Tel: 902-407-3533
Cell: 902-229-6711

Email: welcome@villageonmain.ca

For more information, a detailed report is available upon request.

WWW.VILLAGEONMAIN.CA

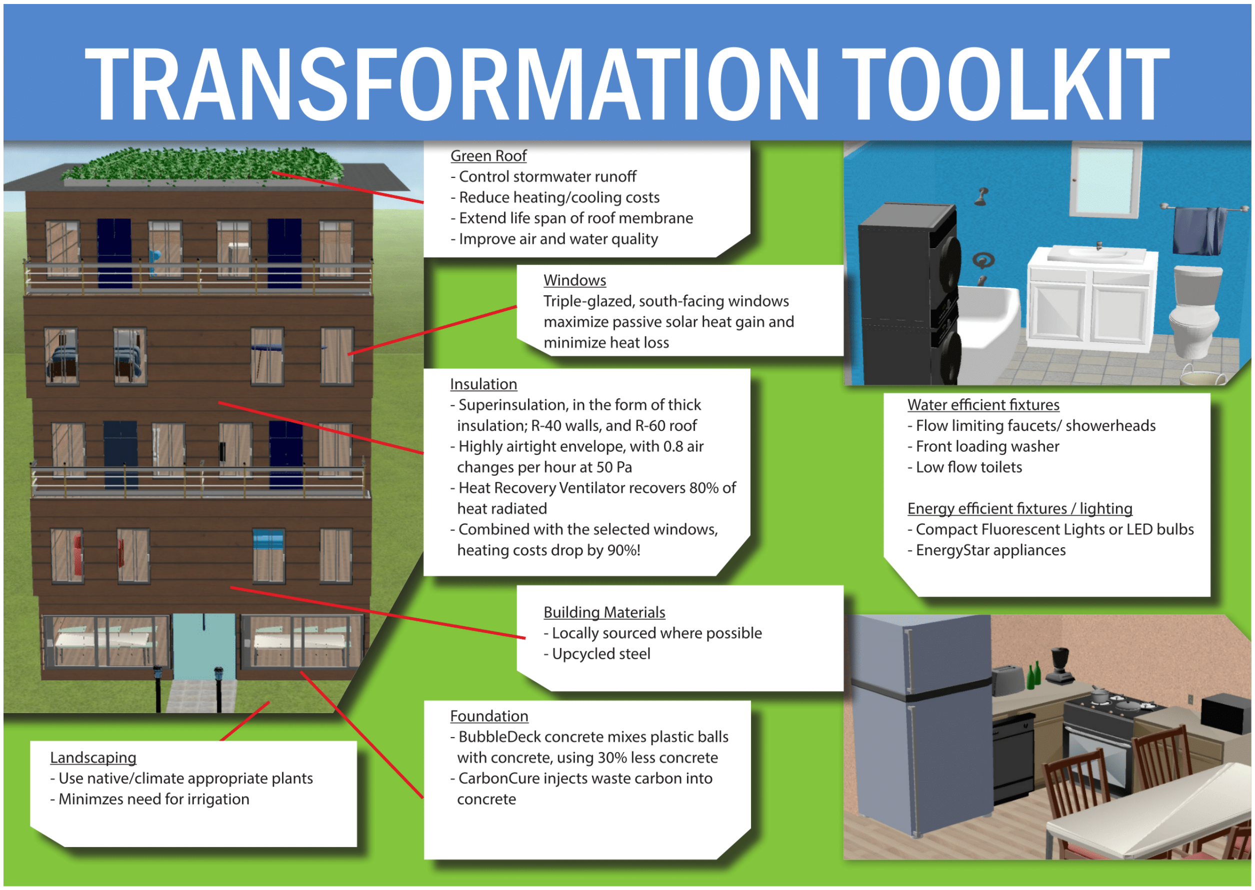
TRANSFORMATION TOOLKIT



The Village on Main

DALHOUSIE UNIVERSITY
College of Sustainability

Appendix C


TRANSFORMATION TOOLKIT
Green Roof
- Control stormwater runoff
- Reduce heating/cooling costs
- Extend life span of roof membrane
- Improve air and water quality
Windows
Triple-glazed, south-facing windows maximize passive solar heat gain and minimize heat loss
Insulation
- Superinsulation, in the form of thick insulation; R-40 walls, and R-60 roof
- Highly airtight envelope, with 0.8 air changes per hour at 50 Pa
- Heat Recovery Ventilator recovers 80% of heat radiated
- Combined with the selected windows, heating costs drop by 90%!
Water efficient fixtures
- Flow limiting faucets/ showerheads
- Front loading washer
- Low flow toilets
Energy efficient fixtures / lighting
- Compact Fluorescent Lights or LED bulbs
- EnergyStar appliances
Building Materials
- Locally sourced where possible
- Upcycled steel
Foundation
- BubbleDeck concrete mixes plastic balls with concrete, using 30% less concrete
- CarbonCure injects waste carbon into concrete
Landscaping
- Use native/climate appropriate plants
- Minimzes need for irrigation