GREENING YOUR HOME

Successful Eco-Renovation Strategies

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Mostly, we want to thank you, the reader, for picking up this book because you care. It is you who holds the future of our marvelous civilization in your hands. Like the raindrop that feeds the river on its way to the ocean, it is your individual decisions that will drive change. Thank you for your commitment to doing the right thing and for your willingness to learn new concepts and explore new ideas. Thank you for having the courage to try.

— Thomas and Laura

Introduction

Building green is not a new idea. While the concept of our carbon footprint and the focus on carbon reduction is fairly recent, many architects and builders have been aware of the environmental consequences of their decisions since the 1970s. Back then, the focus tended to be on pollution and the toxicity of materials, both inside the home and in their places of processing or manufacturing.

During the oil shock of the 1970s, the push to insulate homes was mostly driven by economic considerations and all types of materials were injected into exterior wall cavities, including the dreaded asbestos. Not only was asbestos included in blown-in insulation but it was also embedded in tiles, sheet flooring, and drywall. There were many false starts, and more than a few dead ends on the road to sustainability, some of which turned out to be disastrous and expensive to remediate.

Insulation without proper vapor barriers proved to be functionally short lived as it absorbs moisture condensing inside the walls. Vapor barriers without proper ventilation proved treacherous as it increases the humidity in the home to the point of triggering uncontrolled and often very unhealthy mold growth. Ventilation without heat recovery soon negates much of the benefit of the insulation.

A home built at the turn of the last century was inherently drafty. The inside of the studs and joists tended to be covered with lath and plaster, put there by an arduous process of nailing thin furring strips perpendicular to the studs with gaps of the right proportions to allow the plaster to be squeezed through, expand, or deform slightly, and hook itself into place.

The outside cladding would typically consist of one layer of planking followed by a layer of birch bark, cardboard, or tar paper, on top of which was placed another layer of shiplap siding. Windows were single pane although the frugal among us might have mounted shutters to be closed during storms or at night.

Storm windows that, in the beginning, would be removed in spring and stored until fall were perhaps the first attempt at improving the energy efficiency of a home. It may have become popular because one of the side benefits of installing these often unsightly aluminum additions was that they prevented condensation and ice buildup on the inside of a single-pane window, which allowed for a clear view during the winter months.

Homes in the last century typically housed large and often extended families. Three, four, and even five bedrooms were commonplace. Kitchens were utilitarian, a place where "women folk" or sometimes servants did the messy work. They were usually situated at the back of the house, hidden from view and fully segregated from the stately dining rooms where as many as 10 or 12 people would gather around at mealtime.

Amazingly, these densely populated, 2,500-square-foot homes often were outfitted with only one water closet, usually separate from the bathroom to maximize its accessibility. Vertical slider windows would provide any desired ventilation and a minimum of one "naturally aspiring, fuel fired vented appliance" (as the building code refers to it now) consisting of a wood or coal stove was present to help suck the stale air out of the building.

We remind ourselves of this history to illustrate that much of our current design and building practices have their roots firmly planted in the legacy of the past. There is a story that is told of a little girl who is watching intently as her mother prepares dinner one afternoon. After the onions and carrots are cut into cubes, the mother carefully unwraps the roast, places it on a cutting board and before nestling it into the pan trims off the ends with a sharp knife.

The little girl, resting her chin on her fist as she peeks over the edge of the counter, asks innocently: "Mommy, why do you cut the ends off the roast before placing it into the pan?"

"You know darling, I'm not sure. I've always done it this way because that's how I learned it when I was a little girl. Let's go visit your Nana tomorrow and ask her."

"Nana, Nana, we've come to ask you a question!," the little girl was so excited to be on this quest that she announced their reason for the visit before welcoming hugs were exchanged. "I asked Mommy why she cuts the ends off the roast before putting it in the pan, and she said she learned it from you! Why did you do that, Nana?"

"Good question my child," was the immediate response. "I suppose I learned it from your Great Grandma. Let's call her and ask her shall we?"

The phone rang a good long time before the old woman answered it. But the little girl was patient. "Grandma?"

"Yes darling, how wonderful of you to call!"

"Grandma, I watched Mommy cut the ends off her roast yesterday and she told me that is how she learned it from Nana. Then Nana told me that is how she learned it from you. Why, Grandma, why did you cut the ends off the roast before you put it in the pan?"

"Why that's easy, my darling, I only had one pan and the roast was always too big, so I cut off the ends to make it fit!"

Just because something has been done a certain way for generations does not mean it's the most appropriate method for the times. Humans are not hardwired to cope easily with change. We prefer the well-worn patterns of habit to the treacherous realm of innovation. Tradespeople, designers, and architects tend to build on past practices; often old concepts are simply adapted to new situations without considering their genesis or even their underlying purpose. Of course, it's important to build on the knowledge of the past but this should never dissuade us from asking why, and exploring the deeper issues underlying accepted practices.

We have come a long way since double-pane windows were invented in the 1930s. Over the years improved methods of draft proofing and insulating our homes have reduced our energy requirements. We have learned about energy-efficient appliances and even as we convert our lightbulbs to compact fluorescent lamps (CFL) we recognize that new light-emitting diode (LED) lighting is taking the industry by storm.

We know that turning down our thermostat a couple of degrees and installing low-flow showerheads can save us money on our energy bills. Many of us have at least considered the energy savings of heat pumps and passive solar strategies. For decades now, countless books and magazine articles have touted these "baby steps" to greening our homes.

In this book we want to reach a little further. We start with the premise that your situation is unique, but that you are already aware of the need to reduce your carbon footprint. From there we explore some of the less obvious issues of green design and construction. It is not our intention to focus on specific solutions. Circumstances change from region to region and the best practices of today may be superseded by the new technologies of tomorrow.

Save for a few sojourns into the anecdotes of our building adventures, we will focus on the broader perspective of sustainability. We will explore the hidden carbon and economic costs of bad design and poor practices, and offer you more than a checklist of the right things to do. Our objective is to focus on strategies that you can readily adapt to your circumstances. We want you to develop familiarity with the issues so that whether you do the work yourself or hire experienced professionals, the end result will meet your objectives and expectations.

No doubt you are keen to proceed with turning your ideals into reality. So let's explore the concept of embodied energy and get you started on the right foot as you embark on your eco-renovation!

Note: The forms and checklists included in this book are also provided on the download kit so that you can easily print and use them. See the last page of this book for access to the kit.

1
The Carbon Footprint of Embodied Energy

"You cannot get through a single day without having an impact on the world around you. What you do makes a difference, and you have to decide what kind of difference you want to make."

— Jane Goodall, Ethologist and Zoologist

When we speak of greening our home the first question we are always asked is, "Do you have solar panels on your roof?" Of course solar is a hot topic and as we will discuss in Chapter 8, it has many benefits to help make your home green. However, there is more to the story. Even the second most frequent question, "Is your house super insulated?" leaves out a major element of building and renovating green: Embodied energy.

Before we explore this often overlooked impact on the environment, let's review the operational carbon footprint of a Canadian home. The most obvious is the energy we consume to heat and cool our houses.

According to the Statistics Canada 2011 report entitled, "Households and the Environment: Energy Use,"[1] the total consumption of household energy was about 1.4 million terajoules. This was comprised of electricity (38 percent), natural gas (45 percent), and heating oil (4 percent). Wood, propane, and other energy sources made up the remaining 13 percent. Only 1 percent of households used alternative energy sources such as solar and wind.

In 2011 the average Canadian household consumed 105 gigajoules (GJ) of energy per year. Converted to something we can all understand, this represents about 29,000 kilowatt hours (kWh) per household. That's enough electricity to run 29,000, 1,000-watt baseboard heaters for one hour. Clearly a lot of energy.

Predictably, more occupants per household reduced the energy consumption per capita and households in the top income category consumed twice the energy of households in the bottom. Surprisingly, university educated Canadians used 25 percent more energy per household than those who failed to graduate from high school and the average energy consumption per household varied little with the age of the home. Houses built between 1946 and 1960 averaged 104 gigajoules per household, whereas houses built after 1996 averaged 111.

Since the energy consumption per square meter of a heated area dropped by 16 percent for the same period, no doubt due to the increased efficiency of appliances and improved insulating practices, the reason for the overall increase in energy consumption was a clear trend toward larger homes. The good news is that this trend has started to reverse itself. More and more designers are realizing that not all our living space has to be inside the home and that more efficient use of space can yield huge dividends.

Still, there is much room for improvement in our heating, ventilation, and insulation practices. In 2011, even our lighting was mostly outdated; 41 percent of lightbulbs used in Canada were incandescent and 22 percent were halogen, both high-energy consumers especially when compared to the LED lights now so readily available.

Natural Resources Canada reports that about 60 percent of the energy required by the average home is used for space heating. (In the southern US this might be air conditioning instead.) The second most demanding appliance is your hot water heater, consuming about 20 percent of our annual energy demand. Naturally any green makeover should include insulating and draft proofing against the heat and the

1 "Households and the Environment: Energy Use," Statistics Canada 2011 report, accessed September 2014. http://www.statcan.gc.ca/pub/11-526-s/11-526-s2013002-eng.htm

cold but you may also want to make a super insulated hot water tank and/or a thermal solar water heating system a priority.

There are many burgeoning technologies to consider but the most effective way to make your home as green as possible is to limit its size. Not only does a smaller home reduce the amount of energy it takes to operate but it also reduces the other main contribution to its carbon footprint: Embodied energy.

Note: As does the US Energy Information Administration, Statistics Canada periodically compiles very useful information on household energy use. We use Canadian statistics here as an example because most of the country lives along the 49th parallel and experiences similar climates to the US. You may want to use regional statistics where you live. California is very different from New York State and, when looking for improvements, it helps to know what your neighbors have already been able to achieve.

Be careful when you evaluate statistics. Read the fine print and make sure you understand what the sampling really represents. For example, it's not very useful to combine heating statistics for Alaska and Arizona when you are trying to set the bar for your heating load.

1. What Is Embodied Energy?

Embodied energy is the sum of all the energy required to produce the components that make up your house. Wikipedia describes it as "an accounting method which aims to find the sum total of the energy necessary for an entire product life cycle including raw material extraction, transport, manufacture, assembly, installation, disassembly, deconstruction and/or decomposition, as well as human and secondary resources."[2] Estimates vary but the amount of embodied energy as a percentage of the total energy consumption of your home can range from as low as 25 percent to more than 50 percent.

Because we still produce most of our energy by burning fossil fuels, energy consumption equals carbon emissions. The total carbon footprint of your home is greatly influenced by the amount of energy it took to build it. Here is the catch; if you don't build to last, the embodied energy in your project can counteract any benefits from that added insulation or that gleaming new solar panel.

2. Hidden Energy Consumption

Let's take a closer look at hidden energy consumption. Everything in your home, every nail, hinge, piece of glass, board, and piece of copper

2 "Embodied energy" definition according to Wikipedia, accessed September 2014. http://en.wikipedia.org/wiki/Embodied_energy

wire behind the drywall consumed energy to manufacture, distribute, and transport to the job site. It can be an eye-opening exercise to follow the supply chain back to its beginning. Take nails for instance. If you wander through a modern construction site you will often see clips of them lying about in the mud and hundreds scattered across the plywood subfloor.

The humble nail that you buy at the hardware store has its beginnings in an iron ore mine such as the one in Labrador City, Newfoundland. To extract the iron from the ore and turn it into steel requires a blast furnace capable of reaching temperatures of up to 5,400 degrees Fahrenheit (3,000 Celsius). This is accomplished by burning a coal derivative called "coke" and in the process emitting large sums of CO^2. Almost 70 percent of the world's steel consumption is still produced this way.

The remaining 30 percent is produced in electric arc furnaces using primarily scrap steel which has been recovered from previous uses but which originated in a blast furnace. Red hot bars are extruded from the liquid steel, and then a series of rolling mills reduce the bars to the diameter of wire. Another machine, usually located far from the mill, uses this wire as a feedstock to cut and shape the common nail.

All these processes, the industrial plants and factories that house them, the employees who operate them, as well as the cranes and trucks that transport the final product to us, depend on the consumption of carbon emitting energy. The carbon footprint of a nail is the cumulative carbon emissions of this supply chain amortized over the useful lifespan of the nail.

Another example is the asphalt shingle roof. Sometimes also called composite roofing since the underlying wood fiber-felt substrate has increasingly been replaced with a fibrous glass mat. Both rely on tar and by the time asphalt shingles were invented in 1901 the natural tar used for eons as a sealing and preserving agent had been largely replaced by coal tar, a by-product of the process.

Tar shingles naturally contain polycyclic aromatic hydrocarbons (PAHs) which are known carcinogens that can leach out and contaminate rainwater. For this reason alone, they do not belong on a sustainably built home that aims to capture and store water for use in the garden. While more than 12 million tons of asphalt shingle waste is generated in the United States and Canada each year, the shingles are difficult to recycle and almost all end up in landfills.

Now that we are firmly planted in the twenty-first century it's high time we leave this wasteful technology behind and focus on the new

materials now available. From recycled plastic to solar tiles, from clay shingles to metal roofing, there are many alternatives that will outperform asphalt in the long run and reduce the embedded carbon component of your roof substantially. Metal roofing has the added bonus of being fully recyclable into more metal roofing since it is easy to disassemble and return to the steel mill as feedstock.

When we consider all the materials that go into building a house or addition and follow their individual supply chains, it soon becomes clear that there are many opportunities to green your project by making informed design and purchasing decisions. The embodied energy component extends beyond the cumulative energy requirement of delivering the materials to your site and reaches decades into the future to their final disposal.

What determines the life span of a house? Some say a house can last forever as long as the owner does the necessary maintenance. Others point out that a house becomes obsolete as soon as its owners decide that what it offers no longer satisfies their needs. Along this spectrum, somewhere between these two extremes, lies the complex reality of how long a house will last before it faces demolition.

Your house may well be the biggest investment you will ever make. Naturally, it is prudent to protect its value by making sure it stays in good shape. This goes beyond replacing the leaky hot water tank and curled up shingles from time to time. It reaches deeper than a coat of paint or changing drafty windows.

There is a natural process all around us that clearly delineates between growth and decay. Organic matter is either alive and growing or it is dead and decaying. Inorganic matter is either being formed or breaking down. Since we don't build our dwellings out of growing and forming materials, they are naturally in a state of deterioration. We can slow down that process but we can't stop it.

When thinking sustainably, there is another dimension to this picture. Nature teaches us that the deterioration of all things is a good thing. A dying tree in the forest need not be removed and replaced. It houses a whole ecosystem of life that uses it as food and shelter for years before it falls to the ground. As it continues to rot it helps make fresh soil for new trees to grow. Literally every aspect of the natural world is in a constant state of deterioration, filled with opportunity for newness to reemerge.

When we build or renovate sustainably we do well to be aware of this process. We do this by considering the complete life cycle of not only our house but of every component that makes up its structure

and form. This can be a daunting task and seem overwhelming at first but it need not be. A simple awareness of this principle applied when the opportunity presents itself, will steer your many decisions towards a more sustainable outcome.

The biosphere is a closed system from which nothing escapes. There is no "away" to throw things. Everything you purchase for or consume in your home will form part of the environment for future generations somewhere on our planet. This can be in the form of trash or it can be in the form of a legacy that you can be proud of.

Perhaps one of the first questions to ask yourself is how long should your renovation last? Having taken the initiative to explore sustainable renovation practices you have undoubtedly already progressed past the notion of instant gratification. You may be well acquainted with the sentiment of the "Great Law of the Iroquois," that we should consider the impact of what we do at least seven generations into the future. Maximum sustainability will be achieved if your renovation not only lasts as long as the rest of the house but contributes to extending the life span of the home by making it more resilient and more livable.

In North America the average life span of a residential dwelling is estimated at between 40 and 65 years. In Europe it's easily twice that. Some of that is cultural for sure, but a lot has to do with the choice of materials. For example, new subdivisions and old walled cities share the predominant feature of extremely durable clay tile roofs. Still, one would be hard pressed to find a home more than 40 years old, on either side of the Atlantic, which has not been through at least one major renovation.

Determining the "effective age" of your house is a great starting point when planning your eco-renovation. Perhaps it's still in its youth, simply having gotten off to a bad start. Maybe it's tired and neglected, too crippled to be rejuvenated. Or maybe it's simply facing a profound midlife crisis and, with a little brilliance on your part, can look forward to growing old gracefully.

3. Explore Functionality of Current Design

Renovating sustainably involves exploring the functionality of your current design. Of course, sometimes it requires an addition be built. Often it is more effective to reconfigure the layout of your home, changing the emphasis of living spaces and adapting them to our modern lifestyles. Some architects are now designing smaller homes with this idea in mind. By using advanced materials and techniques to maximize the

span of floors and ceilings, they eliminate the need for interior supporting walls. This makes it possible to renovate extensively and redesign the layout as the home owner's needs and circumstances change.

Sustainable renovation provides an opportunity to reach beyond the simplistic approach of adding more space to store more stuff and explore ways of reducing your carbon footprint while making your home more livable. It may even call for a reduction in the total square footage of your house which can result in a saving of operational costs and, in some instances, maintenance costs as well.

It may also include facilitating sustainable lifestyle strategies such as growing more of your own food or housing bicycles in a conveniently dry and secure part of your home. Both of these adaptations, while not reducing the carbon footprint directly, can help to offset it by encouraging you to reduce the carbon costs of your food and transportation.

4. Where to Draw the Line

When renovating, it is very important to know where to draw the line; generating a smooth transition between old and new offers fantastic opportunities for artistic expression. It's such an important design consideration that it should be addressed early in the project. The transition from old to new must not always be hidden. Highlighting the contrast underscores your commitment to sustainability by demonstrating how to make things last. Remember that everything eventually ends up at the dump and delaying this can extend the amortization of your home's embodied carbon footprint.

One technique that can be used to facilitate this transition is to apply a textured drywall finish. For some inexplicable reason we have become obsessed with clinically smooth, perfectly flat interior wall cladding. It may have started when we invented gypsum board and replaced the textured plaster in our homes with factory produced panels. It may have seemed like the "modern look" in the same way that there was a time when frozen TV dinners were considered modern food.

Do we have to perpetuate this obsession? Clearly not. Making drywall smooth and flat is extremely wasteful. It requires that we minimize the number of seams which increases drywall scrap to ludicrous levels. The National Association of Home Builders in the US calculates that the construction of a 2,000-square-foot home produces 8,000 pounds of waste, most of it wood and drywall (www.epa.gov/wastes/inforesources/pubs/infocus/nf-cd.pdf, accessed October, 2014). When we built our 1,250-square-foot home (750-square-foot footprint) we reused practically all of our scrap lumber multiple times

and produced less than two garbage pails of drywall. Here is how we did it.

First, we realized that splicing drywall on studs is tricky business. Studs are never exactly on center and they are seldom exactly straight. So while the pretty pictures in some how-to books show a drywall splice running down the center of a stud, leaving you three-quarters of an inch to attach the edge of the panel, in real life it's seldom that easy. Walls are often framed with studs that have a slight twist or bow and 16-inch centers are not always diligently observed. Sometimes the studs are milled close to the edge of the tree and still have some bark on them which takes away from the contact surface.

We decided to simply let the drywall progress in full sheets and fasten a scrap of three-quarter-inch board as backing to the splice — less cutting, less measuring, and less scrap. Then we used fiberglass tape for the seams because for the DIY handyperson it's much easier to work with and will never blister or lift. Finally, instead of the endless and dreaded sanding of drywall compound we simply applied the compound in broad, free-flowing strokes to create a textured finish that's a snap to repair.

In nature, there are no truly flat planes. Everything has texture and form. Textures scatter the light and create unexpected shades and hues as the day progresses into night. Just like the old poplar tree in our backyard whose leaves sparkle in the wind as they flash their silvery underside, so our pure white walls constantly change in appearance as they reflect the light of the glulam beams, the colorful furniture, or even the dress of the occupants, in their shifting shadows.

Creating a striking transition from old to new can be a blast and it can go way beyond the style of the wall covering you choose. Be creative, be bold, and be remarkable.

Who said that all the trim in the house has to match or the flooring has to be contiguous? Often a simple line can separate one living space from another while making both spaces appear larger. The line does not have to be straight or predictable. Sometimes that line is not even visible. By its very nature, a renovation requires a transition from old to new. Getting a firm grip on where that line is drawn can save you a lot of time, money, and frustration in the end.

How often have we heard the justification, "But it has good bones!" after a renovation has gotten out of hand? The wood framing of a typical North American home usually makes up only about 10 percent of the cost of construction. Since every component of a home requires carbon emitting energy to produce, and energy is expensive, stripping

down a house to its framing while maintaining an outdated and dysfunctional layout makes little sense.

Still, there are good reasons we should consider the condition of the framing first, especially if you are sure that you want to maintain the current floor plan. Failing studs or plates may require replacing before you can do anything else. Alternatively, if the "bones" are good, you may be able to proceed in stages or phases, selectively addressing yourself to inside and outside cladding as budgets permit.

Another reason to inspect the structural members early is that this may offer clues to the success of the existing cladding and other materials in withstanding the challenges of local conditions. For example, there is a pest that infests older homes in some parts of North America whose acquaintance we made while deconstructing our old house. The wood-boring beetle spends most of its life cycle as larvae inside the framing lumber. Similar to termites, the beetle prefers moist conditions, but once it gets established will spread to dryer sections. The only clues to its presence are a few tiny holes in the timbers where the adult briefly escapes to lay eggs. The larvae, upon hatching, immediately disappear back into the wood. It is quite common to have a dimensionally perfect two-by-four so hollowed out that a child can break it in two.

If you find a serious infestation of these beetles, you likely have a moisture problem that needs to be assessed before you go any further. Not all moisture problems stem from leaks. We will address some of the more serious ones caused by condensation and errant dew points in Chapter 4. As a rule, the best place to look for moisture and check the integrity of your framing is in the attic and wherever you can gain access to the bottom of a first-story exterior wall cavity.

Sometimes this involves removing some drywall. Determining the structural integrity of your home is important. Whether you investigate it yourself or hire a professional to do an assessment, it is well worth the effort and cost. It will provide you with a sense of comfort and some assurance that your finished project can be enjoyed for many years to come, allowing the carbon footprint to be amortized over decades.

What if your renovation turns out to be a compromise that still leaves the house wanting? What if only a few years later you decide that it's too dark, too cramped, or too cumbersome in its layout? What if your choice of materials, fixtures, and trim don't match the perceived value of the home? What if the execution of the renovation lacks the attention to detail that gives it that sense of permanence?

If perfectly good cabinets are removed after only two or three years of service to make room for that grand archway that invites guests into your kitchen, or if that new tub simply does not fit into a larger, more accessible master bathroom that befits the income bracket of a prospective buyer, the renovation could be a colossal failure from an environmental point of view.

Shoddy, poorly designed, and compromising renovations are probably the biggest contributors to the embodied carbon footprint of a house. If the life of a kitchen is cut in half because of poor layout or some other major shortcoming, its embodied carbon footprint is doubled. Should you find yourself at the receiving end of this scenario it is helpful if you cart your used fixtures and cabinets to a recycling facility (e.g., Habitat for Humanity ReStore) or give them to an enterprising couple who is willing to give these components a second life.

When we built our new home we were at the receiving end of such a transaction. A friend of a friend was undergoing a kitchen renovation and removed a perfectly functional double sink which we inherited. Laura used a wire wheel at the end of a drill gun to take the scratches out and her loving care gave it that hand-brushed finish that is usually offered as an expensive upgrade in showrooms.

We also salvaged the Douglas fir flooring in the old house and repurposed it as stair treads in our new home. By preserving the natural patina of the old wood with some sanding sealer and adding a newly milled bull-nose we were able to contrast the old with the new in a stunning display of the longevity of this fine wood. Douglas fir actually gets harder with age; while being fairly easy to mill when new, it can rival some hardwoods for durability.

Salvaging old and used materials is a great way to reduce the embodied carbon footprint of your renovation, but in the end it's not enough. For a greening approach to be fully sustainable it needs to be replicable. We have more than 7 billion people on this planet and if we are serious about reducing our carbon emissions globally, we must all play our part in identifying working solutions that everyone can employ with satisfying results.

When it comes to reducing the embodied carbon footprint of your home, it's important to remember that everything requires energy to produce. Until we progress to harvesting all our energy from the sun in a sustainable way, energy consumption still produces the carbon emissions that drive climate change and ocean acidification.

Let's explore how we can maximize our living space, and build great homes with smaller footprints for a better tomorrow!