



**GREEN BUILDING**  
IN NORTH AMERICA

Paper 4b: Green Residential Building in North America:

A Perspective from the United States

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# 1. Introduction

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## 1.1. Overview

The intention of this paper is to propose a North American vision to promote residential green buildings in Canada, Mexico, and the United States as a way to positively impact global issues such as pollution, dependence on fossil fuels, resource scarcity, loss of natural habitat and species, and climate change. Green building represents one strategy for reducing human impact on the environment. Green buildings can be generally defined as: high-performance, sustainable structures that more efficiently consume and harvest energy, water, and materials while reducing negative impacts on human health and the environment through a holistic approach to design, site usage, construction, operation, maintenance, and deconstruction at the end of a building's useful life.

This section of the housing paper summarizes the current state of residential construction in the United States, including the portion of the market dedicated to green building practices. Following that summary, we present a vision for expanding the green residential market sector in the future. Drivers and barriers associated with green home construction are addressed, and the authors provide recommendations for advancing green residential building in North America.

## 1.2. The Need for Green Housing

Two of the greatest challenges currently facing the global population are climate change and social and economic inequality resulting from resource scarcity. Green housing can begin to address these challenges by integrating the key areas of environmental and human health: protection of ecosystems; preservation of natural resources (including water, agricultural land, timber, minerals, ore, quarry products, and fossil fuels); reduction of atmospheric pollutants associated with energy use and materials manufacturing; and creation of safe, non-toxic indoor environments. A 'whole-building' approach to residential design and construction combines sustainable site design, water conservation, energy efficiency, environmentally preferable materials, and superior indoor environmental quality to achieve a green end product that meets basic human needs for shelter without compromising safety, security, and health needs.

The authors of this paper accept the majority position of the scientific community asserting that human behavior contributes significantly to global warming, and that there is an immediate and urgent need to reduce carbon emissions in order to prevent devastating effects of climate change. Buildings are responsible for almost half (48 percent) of all energy consumption<sup>1</sup> and emit 38

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<sup>1</sup> Architecture 2030: see <<http://www.2010imperative.org>>.

percent of the carbon dioxide<sup>2</sup> in the United States. The authors believe that addressing carbon emissions through the context of buildings is both cost effective and feasible.

In addition to reducing carbon emissions, green buildings can reduce a host of social and economic costs. For example, significant increases in chemical sensitivity have been linked to volatile organic compounds (VOCs) found in building materials and consumer products. Multiple Chemical Sensitivity (MCS) is a syndrome in which a sufferer experiences multiple symptoms upon exposure to minute amounts of everyday chemicals, producing some level of unwellness all the time. Often the chemical concentration that triggers a reaction may be so low that the sufferer can't even smell the substance. Although there are a multitude of triggers for MCS, the products related to the building industry include chemicals emitted by carpets, particleboard, and paints, as well as sealants and adhesives.<sup>3</sup> Healthy, low-emitting alternative materials and superior ventilation are two of the characteristics of green buildings that improve the health of occupants, and in turn lessen the financial burden on families, employers, and insurers.

Although the United States is rich in many resources, it is among the most water-impooverished of all developed nations. The Water Poverty Index ranks 147 countries on a combination of water availability, quality, and use patterns. Canada ranks second-highest in the world behind Finland, with an index of 77.70, while Mexico rates 57.50 for 74<sup>th</sup> place on the scale. The United States ranks 32<sup>nd</sup>, well below most developed and developing nations in Europe and South America.<sup>4</sup> Large areas of arid and semiarid land in the west and southwestern part of the country regrettably coincide with the locations of booming housing markets and increased water demand. Americans also consume 43 percent more water than the average user in other developed countries, and three times more water than the average resident of a developing country.<sup>5</sup> Globally, more than two billion people are expected to live in countries where it will be difficult or impossible to mobilize sufficient water resources to meet the needs of agriculture, industry and households by 2025.<sup>6</sup> Green buildings use strategies to reduce interior and exterior water consumption by 30 to 70 percent.

The examples above illustrate that humans face a range of negative impacts linked to the way buildings are designed, built, and maintained. At the micro level, the need for green housing may be propagated by an individual's health concerns; on the macro level, the need is driven by the climate change crisis facing humanity, and the social unrest and violence resulting from resource

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<sup>2</sup> Environmental Protection Agency, <<http://www.epa.gov/greenbuilding/pubs/gbstats.pdf>>.

<sup>3</sup> Environmental Illness Resource, <<http://www.ei-resource.org/mcs.asp>>.

<sup>4</sup> Keele Economics Research Papers, The Water Poverty Index: An International Comparison, 2002, <<http://ideas.repec.org/p/kee/kerpuk/2002-19.html>>.

<sup>5</sup> World Resources Institute, UN FAO, *Water Resources and Fisheries*, see <[http://earthtrends.wri.org/country\\_profiles/index.php?theme=2](http://earthtrends.wri.org/country_profiles/index.php?theme=2)>, accessed 10 October 2006.

<sup>6</sup> *Environmental Health Perspectives*, see <<http://www.ehponline.org/docs/2004/112-3/forum.html>>.

scarcity. When integrated with improved transportation and eliminating hunger and drought,<sup>7</sup> green building can become a key component to solving the world's greatest challenges.

### 1.3. Benefits of a North American Approach

Beyond the obvious geographic connection, the three countries of North America are linked by the concern that major development in one country can and does have a powerful impact on its neighbors. North American economies continue to become ever more integrated. The three countries share energy dependency and security concerns and all have governments based on liberal democracies. It is imperative that all three governments should approach the issue of development cooperatively.<sup>8</sup> The benefits of this approach are enhanced social, economic, and environmental stability.

Social capital is defined by the networks and interactions that inspire trust and reciprocity among citizens. As a network, green building supports other positive behaviors such as political engagement and volunteering. While social benefits are often more difficult to quantify than economic or environmental benefits, available data suggests that green building is a key component to providing social equity benefits to all members of a society, regardless of economic status.<sup>9</sup> At the Charles Young Elementary School in Washington, DC, implementation of green programs that addressed total environmental quality showed remarkable results: school attendance increased from 89 to 93 percent; math scores increased from 51 to 76 percent; reading scores increased from 59 to 75 percent.<sup>10</sup> This example illustrates the impact of green building on a school community. On a broader level, the benefits of green building strategies can bridge borders between the three nations and provide an avenue for prosperity throughout North America.

### 1.4. Moving Toward Green Residential Buildings

The total United States building stock measures approximately 300 billion square feet. Every year developers in the United States build approximately 5 billion square feet, tear down approximately 1.75 billion square feet, and renovate approximately 5 billion square feet of commercial, institutional, industrial, and residential building space. It has been estimated by the AIA Research Corporation that by the year 2035, approximately 75 percent of the built environment will be either new or renovated.<sup>11</sup> This implies that North America has a unique opportunity over these next years to create a sustainable built environment for present and future generations.

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<sup>7</sup> Technology to feed the world, The National Academies, see <<http://www.nationalacademies.org/webextra/crops/>>.

<sup>8</sup> Building a North American community, see <[http://www.cfr.org/content/publications/attachments/NorthAmerica\\_TF\\_final.pdf](http://www.cfr.org/content/publications/attachments/NorthAmerica_TF_final.pdf)>.

<sup>9</sup> Hyper-mobility, too much of a good thing, see <<http://john-adams.co.uk/papers-reports/>>.

<sup>10</sup> Greener buildings, GreenBiz.com, see <[http://www.greenerbuildings.com/tool\\_detail.cfm?LinkAdvID=66149](http://www.greenerbuildings.com/tool_detail.cfm?LinkAdvID=66149)>.

<sup>11</sup> The American Institute of Architects Research Corporation

Green residential building in the United States has traditionally been a grassroots effort, with origins stemming from the energy crisis of the 1970s and the solar home movement of the 1980s. Though green housing support and certification programs were established on local and regional levels as early as 1991, the concept emerged in mainstream media only in 2006. Rising awareness of global warming has sparked public interest in environmentalism rivaling that of the early conservation movement of the 1970s. Mainstream interest in green building coupled with increased evidence from the scientific and medical communities about the problems associated with a “business as usual” approach indicates that this trend is destined to stay.

In typical response to controversy, an exciting array of green solutions and opportunities has been proposed by entrepreneurs and innovators. Consumers are engaged in finding greener options for food, transportation, and building. Interest in green housing manifests itself in diverse ways: builders and developers satisfying a demanding homeowner; advocacy groups developing certification and recognition programs; banks and lenders recognizing a unique marketing tool; designers and architects tapping new and exciting technologies and resources; government agencies enacting green building incentives and mandates; and academia and the research community developing new products and systems. Part of this change is due also to a more vocal source: an increased celebrity presence in all matters green, from choice of transportation to homebuilding. Green building advocates, including the authors of this paper, believe that given proper support from government and marketplace, sustainable housing can become the status quo in the near future.

## 2. Background Facts

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### 2.1. The United States Residential Sector

The US Census Bureau’s 2005 survey of the nation’s housing stock showed approximately 124 million units nationwide, of which 68 percent are single-family residences, 25 percent are multi-family dwelling units, and roughly 7 percent are manufactured homes. 68 percent of all housing units are owner-occupied, while 31.2 percent are rental units.<sup>12</sup> It is estimated that 2.43 million new housing units were constructed in the United States in 2006.<sup>13</sup> The majority of the construction occurred in the densely populated southern and western regions of the country, which exacerbates the challenges faced by these already burdened environments. Although individual single-family residences are small in size when compared to commercial or industrial buildings, the aggregate economic, social, and environmental impact of housing is significant. The housing industry represents \$425.2 billion (61 percent) of the value of all US building

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<sup>12</sup> US Census Bureau. American Housing Survey for the United States: 2005. See <<http://www.census.gov/prod/2006pubs/h150-05.pdf>>.

<sup>13</sup> National Association of Home Builders: Facts and Photos. See <<http://www.nahb.org/page.aspx/generic/sectionID=151>>.

construction,<sup>14</sup> making it one of the largest and most powerful engines of economic growth in the country.

By far the most common form of housing in North America is the *single-family* detached residence, ranging from 600 square foot bungalows to 10,000+ square foot sprawling mansions. Large or small, the single-family home has become embedded in the US citizen's psyche as a part of the American Dream. Eighty-five percent of single-family residences are owner-occupied.<sup>15</sup> Construction types vary by region, although over 90 percent of single-family homes in the United States are framed with wood.<sup>16</sup> Light-gauge steel, concrete block or cast-in-place concrete homes are increasingly popular in markets such as Florida, where termites and moisture make inorganic building materials more attractive. Specialty manufactured products, such as modular homes or structural insulated panel (SIP) houses, have established market share as a lack of skilled labor and high quality lumber affect the traditional wood framing industry. Housing components made in factories tend to have better quality control than site-built products, and these components are increasingly being used by custom homebuilders, in conjunction with high-end or high-performance features. Many green homes feature these less traditional construction types.

Single-family homes owe their diversified aesthetic to the influences of the varied cultures that have populated the United States regionally. The Cape Cod, the Colonial, the ranch, and the craftsman's bungalow are among the best known styles of American single-family homes. Whether the aesthetic is traditional or minimalist, modernist architecture, single-family homes today incorporate increasingly advanced technological building tools.

*Multi-family* housing also varies in style and structure according to region and era, but this type of dwelling typically has a more utilitarian aesthetic. Multi-family buildings have at least two dwelling units sharing a common exterior envelope, and can range in size and shape from sprawling low-rise to urban high-rise. Framing materials vary based on project location and configuration, but new buildings less than six stories high are often at least partly wood-framed. Dense urban centers such as New York City do not allow wood for structural purposes in residential construction, so concrete block-and-plank or steel frame construction are more popular in these areas.

Though renters still occupy 85 percent of units,<sup>17</sup> rising single-family home prices and attractive financing have helped make ownership of multi-family housing more attractive in recent years. Condominiums, duplexes and other multi-family units are generally 25 to 30 percent more

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<sup>14</sup> US Department of Energy, Energy Efficiency and Renewable Energy. *2006 Buildings Energy Data Book*. Available at <<http://buildingsdatabook.eren.doe.gov/>>. Values exclude industrial buildings.

<sup>15</sup> US Census Bureau. American Housing Survey for the United States: 2005, <<http://www.census.gov/prod/2006pubs/h150-05.pdf>>

<sup>16</sup> Forest Products Journal, Volume 49 Number 9.

<sup>17</sup> US Census Bureau. American Housing Survey for the United States: 2005. <<http://www.census.gov/prod/2006pubs/h150-05.pdf>>.

affordable than single-family detached units; although, recent heavy demand for this diversified housing form is closing the gap. In California, for each decade during the period from 1960 to 1990, the ratio of multi-family construction to single-family construction was nearly two-to-one before the trend stalled from 1990 to 2000. To meet rising demand, California has implemented a new model to encourage investment in both affordable and market-rate multi-family housing, including real estate investment trusts (REITs), development trusts which finance, purchase and manage affordable housing properties.<sup>18</sup> Another positive indicator in multi-family development is the rehabilitation of dilapidated sites. While most of the multi-family reuse projects are in urban settings, they are increasingly occurring in smaller towns and rural areas, especially when the reused property has historical significance.<sup>19</sup>

**Manufactured housing**, also known as mobile or HUD-code homes, are manufactured in an industrial setting and transported via semi-trailer to a residential site. Manufactured housing is regulated by the United States Department of Housing and Urban Development (HUD), via a 1974 piece of legislation that allows manufacturers to distribute nationwide, independent of variations in state and local building codes. Typically consumers turn to manufactured housing when ownership of a traditional home becomes financially infeasible.<sup>20</sup> The number of manufactured housing units grew substantially from 315,000 in 1950 to almost 8.8 million by 2000. The peak of mobile home growth was in the 1970s and 1980s, when their number increased over 2.5 million during each decade before growth slowed in both percentage and absolute number in the 1990s.<sup>21</sup> Currently in the United States approximately 117,000 manufactured housing units are being shipped per year. Although manufactured housing units are less popular in Canada than in the United States, these structures offer an affordable housing solution to those individuals who may have difficulty financing a mortgage for a traditional home. Manufactured homes are found in every province and territory and over half of Canada's units are located in British Columbia and Alberta.<sup>22</sup>

**Renovation and remodeling** is another important aspect of residential construction. Despite the 2.5 million new housing units built in the United States last year, a report released by the Center for Policy Alternatives states that approximately 30 percent of the housing units in the United States are more than 50 years old and about 75 percent are more than 25 years old. About 200,000 housing units are being abandoned or destroyed each year.<sup>23</sup> As housing stock ages, the need to update and modernize these buildings to meet performance standards and changing

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<sup>18</sup> INF21 Supply of affordable multi-family housing is inadequate. *California Performance Review*. See <<http://cpr.ca.gov/report/cprprt/issrec/inf/inf21.htm>>.

<sup>19</sup> Multi-family Residential Development:

<[http://www.architecturalteam.com/portfolio/project\\_list\\_pdf/MultifamilyResidential.pdf](http://www.architecturalteam.com/portfolio/project_list_pdf/MultifamilyResidential.pdf)>.

<sup>20</sup> US Census Bureau, from a survey by the US Department of Housing and Urban Development. <<http://www.census.gov/const/mhs/shipment.pdf>>.

<sup>21</sup> US Census Bureau. See <[http://factfinder.census.gov/jsp/saff/SAFFInfo.jsp?\\_pageId=tp13\\_housing\\_physical](http://factfinder.census.gov/jsp/saff/SAFFInfo.jsp?_pageId=tp13_housing_physical)>.

<sup>22</sup> Wade, P.J., Mobile homes increasingly popular in Canada, *RealtyTimes.com*. <[http://realtytimes.com/rtpages/20010925\\_mobile.htm](http://realtytimes.com/rtpages/20010925_mobile.htm)>.

<sup>23</sup> *Progressive Agenda for State Housing Policy: 2007*. Center for Policy Alternatives. Washington, DC. <<http://www.stateaction.org/publications/agenda/2007/2007housingpolicy.pdf>>.

homeowner expectations becomes critical. Despite a recent slowdown in new housing starts during 2005-2007, US home owners continued to remodel. Home improvement spending grew by 4.5 percent in 2005 and again by 4 percent in 2006, with an annual investment of \$149.5 billion, according to Harvard's Joint Center for Housing Studies.<sup>24</sup> The popularity of housing renovation can be attributed to a number of factors. Equity in existing homes helps to finance housing improvements. Accommodating elderly occupants with more accessible design or adding a home office to facilitate telecommuting are popular renovation projects.<sup>25</sup> Additionally, tax rebates and utility-sponsored incentives make home remodeling projects that enhance energy efficiency more attractive.

Significant opportunities currently exist in Canada, Mexico and the United States to impact the renovation and/or rehabilitation of existing housing stock in each country. During the last three years in Canada, homeowners have spent more money on remodeling their homes than ever before. The Canada Mortgage and Housing Corporation estimated Canadians spent over 38 billion Canadian dollars (about US\$36 billion) in home alterations, improvements, and repairs in 2004. Although housing statistics from Mexico are more difficult to obtain due to the informal or self-built sector and lack of observable sales transactions, a 2004 Harvard University study estimated the nation's existing housing stock at 24 million units, with an estimated value of more than P\$1.1 trillion (about US\$110 billion).<sup>26</sup> The study goes on to report that roughly two-thirds of existing homes are self-built by homeowners, and many are in poor condition and in need of significant upgrades.

## 2.2. Environmental Impacts of Standard Housing

The construction and operation of buildings, specifically residential buildings, requires significant input of energy, water and raw materials. Buildings are also responsible for considerable quantities of waste and emissions, including greenhouse gases. In 2005, the US Department of Energy reported that the average family in the US spends \$1,291 on home energy each year, and those costs are rising rapidly. The National Association of Home Builders reports that at 2400 square feet, the average home is nearly double its 1970 size. That average US residence produces an incredible 12.4 tons of carbon dioxide from its household operations,<sup>27</sup> a figure six times the average of the rest of the world. Table 1 illustrates some of the environmental impacts resulting from current building practices.

**Table 1.** Comparison of Environmental Impacts from Building Construction and Operation

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<sup>24</sup> Research: Remodeling. Joint Center for Housing Studies. Harvard University Graduate School of Design. <<http://www.jchs.harvard.edu/research/remodeling.html>>.

<sup>25</sup> AIA. Home Designs Trends Survey. <[http://www.aia.org/aiarchitect/thisweek07/0504/0504b\\_res.cfm](http://www.aia.org/aiarchitect/thisweek07/0504/0504b_res.cfm)>.

<sup>26</sup> *The State of Mexico's Housing, 2004*. Joint Center for Housing Studies of Harvard University. <<http://www.jchs.harvard.edu/publications/international/som2004.pdf>>.

<sup>27</sup> How do we contribute individually to global warming? Hinkle Charitable Foundation, Report 5. <<http://www.thehcf.org/emaila5.html>>.



Environmental Impacts	All Buildings <sup>28</sup>	Residential Sector
Energy Consumption, primary- percent of US consumption <sup>29</sup>	39	21
Electricity Consumption, primary- percent of US consumption <sup>30</sup>	71	36
Natural Resource Consumption:		
Water - percent of all potable water <sup>30</sup>	12.2	5
Raw Materials- percent of global resources <sup>31</sup>	40	
Wood - percent of US consumption <sup>32</sup>	50	40
US construction, renovation, and demolition (C&D) waste <sup>33</sup> (million short tons/yr)	136	58
Toxic Emissions (10 <sup>6</sup> short tons/yr) <sup>30</sup>		
SO <sub>2</sub>	7.919	
NO <sub>x</sub>	4.078	
CO	2.856	
CO <sub>2</sub> (10 <sup>6</sup> metric tons/yr) <sup>30</sup>	608.1	329.8
- Percent of US emissions	38	20
- Percent of global emissions	10	5

**Energy use** is the most widely recognized metric for evaluating housing performance, in part because it is easily quantified. In the United States the residential household relies primarily on three sources of energy: natural gas, electricity (mainly derived from coal), and fuel oil. Though energy needs vary based upon housing type, climate, and occupant behavior, most of the energy consumed by residential buildings is due to space heating and heating of water, approximately

<sup>28</sup> For energy and emission data, “all buildings” refers to commercial and residential structures; industrial buildings are excluded. Energy and emissions data is for primary energy consumption (i.e., energy consumed at the site and for electrical generation and distribution).

<sup>29</sup> US Department of Energy, *2007 Buildings Energy Data Book*. See <<http://buildingsdatabook.eren.doe.gov/>>.

<sup>30</sup> US Geological Survey, 1995 and 2000 data.

<sup>31</sup> Lenssen and Roodman, 1995. *A Building Revolution: How Ecology and Health Concerns are Transforming Construction*. Paper 124: Worldwatch Institute.

<sup>32</sup> US Department of Commerce, 1993, and Nebraska Energy Office, *Minimizing the Use of Lumber Products in Residential Construction*. <[http://www.neo.ne.gov/home\\_const/factsheets/min\\_use\\_lumber.htm](http://www.neo.ne.gov/home_const/factsheets/min_use_lumber.htm)>.

<sup>33</sup> US Environmental Protection Agency. 1996 estimate. <<http://www.epa.gov/epaoswer/non-hw/debris-new/basic.htm>>. HARC website: <<http://www.harc.edu/Projects/Archive/CultivateGreen/Events/20050518>>.

48.8 percent and 15.4 respectively.<sup>34</sup> Other average uses include lighting (6.9 percent), cooling (6.4 percent), refrigeration (4.6 percent), cooking (4.1 percent), and electronics (2.9 percent).

In the past several decades, US household *electricity consumption* has grown dramatically. Retail sales of electricity to US households exceed sales of electricity to the commercial and industrial sectors. Although local and national energy efficiency standards have grown increasingly stringent, the prevalence of older equipment with significant lifespan (such as refrigerators) and changing consumer patterns are leading to an overall increase in consumption. It is projected that given current patterns, electricity delivered to the residential market will increase 68 percent between 2003 and 2025. Continued growth of new housing in the southern and western regions of the United States, where almost all new homes use central air-conditioning, is expected to contribute to an increase in household electricity demand. Consumption for home electronics, particularly for color TVs and computer equipment, is forecasted to increase by 3.5 percent through 2025 to more than double the level of consumption in 2003.<sup>35</sup>

Energy consumed in housing is associated with several *emissions and pollutants*; carbon dioxide is emphasized because of its connection to climate change. Electricity consumed in US homes is generated primarily from coal (nearly 50 percent), with lesser portions from nuclear power and natural gas (each about 19 percent), hydroelectricity, and petroleum (less than 10 percent combined).<sup>36</sup> Coal has the highest carbon intensity among electricity generating fuels. In the United States, the average output rate for coal-fired electricity generation is approximately 2.1 pounds of CO<sub>2</sub> per kilowatt-hour. In recent years petroleum has produced as much as 119 billion kilowatt hours for the United States at a cost of 106 million metric tons of CO<sub>2</sub> emissions, making it the second biggest polluter at 1.9 pounds of CO<sub>2</sub> per kilowatt hour. The least polluting fossil fuel, natural gas, emits 1.3 pounds of CO<sub>2</sub> per kilowatt-hour.<sup>37</sup> As non-fossil fuel alternatives, nuclear power and hydroelectricity have no CO<sub>2</sub> emissions but pose other environmental concerns and compromises.

*Water consumption* in a typical single-family home varies dramatically, and measurement of individual end use events is difficult. On average, indoor water use for the typical home amounts to 63.8 gallons per person, per day. Outdoor residential water use can account for more than 30 percent of the entire water usage for the home.<sup>38</sup> The average US home can reduce indoor water use by approximately 32 percent by installing readily available water efficient fixtures and

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<sup>34</sup> 2006 Buildings Energy Data Book, 1.2 Residential Sector Energy Consumption.  
<<http://buildingsdatabook.eren.doe.gov/docs/1.2.3.pdf>>.

<sup>35</sup> Energy Information Administration, *US Household Electricity Report*.  
<[http://www.eia.doe.gov/emeu/repse/enduse/er01\\_us.html](http://www.eia.doe.gov/emeu/repse/enduse/er01_us.html)>.

<sup>36</sup> The Energy Information Administration. <[http://www.eia.doe.gov/cneaf/electricity/epm/epm\\_sum.html](http://www.eia.doe.gov/cneaf/electricity/epm/epm_sum.html)>.

<sup>37</sup> *Carbon Dioxide Emissions from the Generation of Electricity in the United States*,  
<[http://www.eia.doe.gov/cneaf/electricity/page/co2\\_report/co2emiss.pdf](http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2emiss.pdf)>.

<sup>38</sup> *A Source Book for Green and Sustainable Building*,  
<<http://www.greenbuilder.com/sourcebook/IndoorWater.html>>.

appliances and taking measures to minimize leaks.<sup>39</sup> In addition, research indicates that a typical household wastes between 8,000 and 10,000 gallons of water a year while the occupant is waiting for hot water to arrive at the tap.<sup>40</sup>

With the US landscape increasingly covered by the footprint of buildings, nearly all major cities experience a substantial problem with stormwater run-off. Because paved areas and building footprints leave little permeable, green space water is no longer absorbed into the ground but is instead directed immediately into storm drains, and then major waterways, causing them to rise much faster than they would had the water been absorbed into the soil. Not only does the run-off increase the possibility of flooding; it also creates a significant problem with water quality. When stormwater and sewer systems were first built in most cities it was to accommodate more permeable plans; as run-off has increased, the system no longer has the capacity to handle the extra volume. This causes the rainwater to mix with the sewage, and in cities around the United States (including Washington, DC) the overwhelmed sewage treatment plants are forced to expel diluted and untreated sewage directly into rivers and lakes (like the Anacostia and the Potomac Rivers).<sup>41</sup> Urban sprawl and poor development practices have caused major disruption to natural watersheds. Single-family homes with groomed, pesticide-sprinkled lawns are typically built on lots with little permeable surface. In Schuylkill, Pennsylvania, 34,000 hectares of forest and agricultural land were urbanized, resulting in a 31 percent increase in developed land. Chloride levels corresponded with a 37 percent increase and the Schuylkill River had the fastest increase in nitrate levels and residuals over all other watersheds in the Northeast.<sup>42</sup>

Another major byproduct of residential buildings is the *waste* generated during construction, demolition, and renovation. A study conducted for the United States Environmental Protection Agency found that 136 million tons of debris was generated in 1996 by construction and demolition (C&D) waste.<sup>43</sup> Residential construction activities accounted for 43 percent of the nation's total waste, or 58 million tons per year. Demolition of all building types accounted for 48 percent of the total waste stream; renovation activity accounted for 44 percent; and 8 percent of the waste stream was attributed to new construction. Within the residential sector, new construction produced 11 percent, demolition accounted for 34 percent, and renovation activity contributed a staggering 55 percent of the total residential C&D waste stream.

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<sup>39</sup> Water use inside the home. Department of Water Resources, Washoe County, Nevada. <<http://www.washoecounty.us/water/wtrconservation/usage.htm?PHPSESSID=5d15340fbc8d8b48449f854ad579b9e6>>.

<sup>40</sup> Residential construction: Water use. Pollution Prevention Information Center. <<http://www.peakstoprairies.org/topic/subsection.cfm?hub=31&subsec=13&nav=13&CFID=8735425&CFTOKEN=85811439>>.

<sup>41</sup> Cleaning up the Anacostia River. National Resources Defense Council. See <<http://www.nrdc.org/water/pollution/fanacost.asp>>.

<sup>42</sup> Hazardous to our health: The effects of urban sprawl on the environment and its Inhabitants. See <[http://sitemaker.umich.edu/section9group3/files/erin\\_and\\_kayla.ppt#292](http://sitemaker.umich.edu/section9group3/files/erin_and_kayla.ppt#292)>.

<sup>43</sup> Residential construction and demolition waste, Houston Advanced Research Center website: <<http://www.harc.edu/Projects/Archive/CultivateGreen/Events/20050518>>.

Lumber is the most popular *raw material* used in US housing construction. American buildings account for 40 percent of global raw materials<sup>44</sup> and within the United States, the Commerce Department has reported in the past that 50 percent of the wood consumed was for building, specifically residential construction. When the average US home size was 1200 square feet, approximately five 10-year-old Southern pines were required to build a single house.<sup>45</sup> Given that today's average home size is around 2400 square feet. The authors of this paper estimate that 13 million 10-year-old Southern pines are required to build the 1.3 million new, wood-framed homes in the United States each year. Today's builders and manufacturers compensate for a shortage of high-quality mature trees by utilizing engineered wood products. Trusses, joists, headers, and structural wall paneling are factory-produced alternatives that provide high-quality members from scrap and small-dimension lumber. However, the addition of formaldehyde resins (a known human carcinogen) in the binders of engineered wood products raises a number of health concerns for workers and end users of the materials. Safer alternatives are being developed and becoming more readily available.

### 3. Green Housing Targets and Impacts

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#### 3.1. Green Residential Building Movement

Industry leaders and advocacy groups acknowledge a critical need to correct the unsustainable business-as-usual approach to residential building. Traditionally, green housing support programs have developed through grassroots efforts. Forward thinkers in the residential building sector recognized the value of establishing certification programs for green building in the United States as early as 1990 when Austin Energy's Green Building Program® was established. Since that time, approximately 85 regional green residential building programs have been developed around the country. In some instances, local and regional green home certification programs have significantly transformed regional marketplace and placed "green" at center stage for developers, builders, and homebuyers. Several of the preeminent green regional programs in the United States are described below.

***Austin Energy Green Building Program®*** was the first green building program and is today the most successful utility-sponsored program in the nation. The program was certifying 700+ homes per year as early as 2000, and continues to increase its numbers. Its top tier is among the most stringent of all US green home programs, though the program offers three additional tiers at more accessible levels.<sup>46</sup>

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<sup>44</sup> Get into green, National Building Museum: <<http://www.nbm.org/Exhibits/greenHouse2/greenHouse.htm>>.

<sup>45</sup> How many trees does it take to build one house? FunQA: <<http://www.funqa.com/environment-ecology/1156-Environment-2.html>>.

<sup>46</sup> Austin Energy Green Building Program. See <<http://www.austinenenergy.com/Energy%20Efficiency/Programs/Green%20Building/index.htm>>.

**Built Green® Colorado** was introduced in 1995. The program was created through partnership between the Home Builders Association of Metro Denver (HBA), The Governor's Office of Energy Management and Conservation (OEMC), Xcel Energy, and E-Star Colorado. The program has successfully courted production builders throughout the area, resulting in certification of over 33,000 homes by the end of 2006, thanks in part to a sampling and verification process that helps keep certification costs affordable. Built Green® is acclaimed within the industry for its advertising campaigns geared toward both builders and homebuyers.<sup>47</sup>

**EarthCraft House™** is a partnership between Southface Energy Institute and the Greater Atlanta Homebuilders Association. The program has been successful in courting production builders and has certified over 3,500 homes. Southface adheres to a thorough verification process that requires a visual inspection of each certified home. The National Association of HomeBuilders named Earthcraft House™ “Green Building Program of the Year” in 2004.

Local and regional green home programs paved the way for all manner of green building standards in the United States, but they are not without their hurdles. With a wide array of programs available, “green” has taken on a vast range of meanings. Consumers may not adequately recognize brands, and builders operating in multiple markets are reluctant to comply with multiple green building standards. In 2005, residential green building standards entered the national stage for the first time with the following programs.

**NAHB Model Green Home Building Guidelines** developed by the National Association of Homebuilders (NAHB) were released early in 2005. The NAHB announced in Spring 2007 its intention to turn the Guidelines into a national rating system, implemented by local Homebuilder Association chapters. The Guidelines serve as a solid educational piece for builders less familiar with green building concepts. To ensure that builders achieve a balanced, green residence, the NAHB guidelines set Bronze, Silver, and Gold performance levels in each of the major categories (including site, water, energy, and so on). The guidelines heavily emphasize durable construction techniques based on building science research. They target the mainstream builder audience, rather than those in favor of more stringent green home standards. NAHB and the International Code Council (ICC) announced in February 2007 their intention to jointly develop an American National Standard for residential green building based on the NAHB Model Green home Building Guidelines, a major development in the US green housing scene.

**LEED for Homes™**, currently in pilot phase, represents the US Green Building Council’s (USGBC) first Leadership in Energy and Environmental Design (LEED) product focused on residential buildings. In recent years, USGBC has emerged as a dominant US brand in green building rating systems for commercial buildings. LEED for Homes targets the top 25 percent of homes with best-practice environmental features. Usually these are built by builders who have already mastered whole-house energy performance at ENERGY STAR Labeled Home levels (a prerequisite of LEED for Homes) and are interested in raising the bar in other areas of

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<sup>47</sup> Built Green Colorado: See <<http://www.builtgreen.org/>>.

sustainability, including water conservation, indoor environmental quality, and materials selection. In addition to meeting all mandatory requirements, builders select from a list of optional credits to earn points toward a Certified, Silver, Gold, or Platinum rating. The LEED for Homes pilot was launched in select markets late during Summer 2005, and the final version of the standard will be rolled out nationwide in November 2007. LEED for Homes can be applied to a range of housing types, from single-family residences to mid-rise multi-family buildings. As of June 2007, 393 builders around the country had enrolled approximately 6,300 housing units in the green building program, and 220 housing units had been officially certified.

The authors have observed several industry trends among the US regional and national green building programs during the last two years, as illustrated in Table 2 below.

**Table 2:** Trends in US Green Residential Building Programs

Observed Trends in Regional and National Green Certification Programs	
Increasing Number of Programs	The number of regional green home programs continues to grow, started by utilities, environmental organizations, and municipal groups. Typically, these programs try to appeal to a broad builder base and emphasize local concerns.
Stringency	Local and regional green building programs are generally more inclusive and less stringent than LEED for Homes. NAHB criteria may be more similar, but their requirements for some mandatory items in every category may make them more comprehensive than many local programs.
Production Building	Green building programs in Denver, Austin, Wisconsin and Florida have successfully worked with large production builders that constitute the vast majority of certified homes in these regions. Where large builders are uninterested or deem the standards too difficult, green building programs suffer. The NAHB guidelines could potentially have strong resonance with the organization’s production builder membership. Production builders have also signed on to LEED for Homes, though the number of individual custom builders registered far outweighs the number of individual production builders. Most LEED for Homes activity on the community and production scale has occurred in California and the Northeastern states.
Brand Recognition	While Austin Energy Green Building Program and Built Green Colorado have achieved significant brand recognition among builders and buyers in their regions, most other local and regional green building programs struggle with a lack of brand recognition among both consumers and builders. National builders imply that confusion over which standard to follow, or the difficulty in adhering to different local programs in different markets, is a deterrent from undertaking green building. This may be a legitimate lack of understanding, or a convenient excuse.

Maintenance Challenges	Local green building programs typically rely on volunteers to screen and maintain checklists and program criteria. Some programs see national standards like LEED for Homes and the NAHB Guidelines as a potential way to relieve some of the burden associated with maintaining and updating a green standard. Built Green Colorado, the Florida Green Building Coalition, and EarthCraft House are among those organizations doing double duty as both regional green standard providers and LEED for Homes Pilot Providers. Post-pilot, well-established programs may maintain both options for regional builders; programs with fewer resources may choose to adopt and implement just one program.
Incentives	While incentives for high-performing homes have typically been energy-based and funded by utilities or national Tax Credits, municipalities are starting to offer incentives for environmental performance. In Chicago, where building permits can take weeks, buildings designed to meet LEED criteria get fast-track permitting in as little as 15 days. <sup>48</sup> During spring 2007, a number of cities and states, including Las Vegas and New Mexico, were developing legislation for substantial green housing tax credits for homeowners.
Mandatory Green Home Standards	Though still very rare, municipalities such as Boulder, Colorado, and Frisco, Texas, have adopted green standards that require compliance for issuance of a building permit. Municipalities are investigating the adoption of mandatory green home standards but the trend is currently to create a customized standard (typically fairly lenient) rather than adopt an existing standard. This trend may change as more homes successfully comply with national standards.

### 3.2. Market Penetration of Green Housing

According to US Census Bureau data, the number of housing starts for the year ending November 2006 indicated an overall continued decline in the US housing market. Despite the current slowdown, green homes have been rapidly gaining market share during the past several years. A June 2007 survey from NAHB indicated that 97,000 green residences had been built and certified under voluntary regional and national green building programs since the early 1990s.<sup>49</sup> This number shows a marked increase from NAHB's 2005 estimate that 61,000 green houses were built between 1990 and 2004. The green home building market comprises approximately 0.3 percent of the housing market in the US and is expected to rapidly increase in the near future due to high consumer satisfaction and growth in the number of green builders.<sup>50</sup>

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<sup>48</sup> Chicago expedites permits for green buildings, McGraw-Hill Construction: <[http://www.aia.org/static/state\\_local\\_resources/adv\\_sustainability/Permitting%20and%20codes/Chicago\\_Permit\\_article.pdf](http://www.aia.org/static/state_local_resources/adv_sustainability/Permitting%20and%20codes/Chicago_Permit_article.pdf)>.

<sup>49</sup> Nearly 100,000 green homes certified through market-driven green building nationwide, says NAHB, National Association of HomeBuilders, News, 6 June 2007, <[http://www.nahb.org/news\\_details.aspx?newsID=4776](http://www.nahb.org/news_details.aspx?newsID=4776)>.

<sup>50</sup> In addition to the increase in green new construction, homeowners are increasingly using environmentally sensitive materials to remodel their homes. For example, a survey by McGraw-Hill (see next reference) indicates that 39 percent of homeowners are using green products when remodeling their homes.

A recent market report by McGraw-Hill Construction estimated that two percent of new houses nationwide incorporated some energy efficiency or green features.<sup>51</sup> The report also estimated that the number of green housing units would grow by 20 percent in 2006 and another 30 percent during 2007 so that by the end of 2007, more than two-thirds of US residential builders would be incorporating green elements from at least 3 of 5 categories (including energy, site, water, materials, and indoor air quality) into new construction and remodeling projects. The authors feel these estimates are misleading; green housing requires an integrated whole-building approach to address multiple aspects of home performance, environmental impacts, and health and safety rather than three green products. The authors have found that builders tend to refer to certain now-standard products as “green” if they meet more stringent performance criteria than in years past. For example, beginning in January 2006 the US Department of Energy required that all central air conditioning units for low-rise residential applications must meet a Seasonal Energy Efficiency Ratio (SEER) of at least 13. For many builders, SEER 13 represents an efficiency improvement from prior standard practice.

The market penetration estimates discussed above include those homes that earned the ENERGY STAR label under the efficiency program operated by the US Department of Energy and the US Environmental Protection Agency. By far the most successful initiative in the nation to address superior building performance, the label was applied to 350,000 homes during the ten years following its inception in 1995 and 1 in 10 homes during 2004. Local and regional green building standards often build upon the existing ENERGY STAR platform.

### 3.3. Characteristics of Green Housing

One way in which the US housing market is transforming can be seen by the definition of a “green” residential building. In the environmental movement of decades past, individuals in pursuit of sustainable living would flee the city and go “back to the land”; whereas today “green” building is often associated with regenerative uses of urban properties. As transportation and home energy costs increase and available land decreases, developers and consumers alike are turning to *smart growth* principles. Brownfield redevelopment, transit-oriented communities, mixed use development, and urban infill are increasingly common for residential buildings. According to January 2007 construction data, multi-family, mixed use, and transit-oriented developments were unaffected by the broader housing market downturn.<sup>52</sup> High-density urban centers are leading the way in ecological and productive cooperation, utilizing high-tech design solutions and efficient resources. US cities compete against one another to embrace “green” faster and better, and the wave of green building practices is flooding into the suburbs and beyond. Vying for top spots among the greenest cities in the United States are some of America’s oldest municipalities, including Boston and Chicago. New York City has already

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<sup>51</sup> McGraw-Hill Construction, *Residential Green Building SmartMarket Report: 2006*, <[http://construction.ecnext.com/coms2/summary\\_0249-87264\\_ITM\\_analytics](http://construction.ecnext.com/coms2/summary_0249-87264_ITM_analytics)>.

<sup>52</sup> Reed Construction Data, January 2007. See <<http://www.reedconstructiondata.com/>>.



measured higher average temperatures in Central Park and elevated sea levels at Battery Park, giving the city “about 8 million reasons to take climate change seriously.”<sup>53</sup>

The most commonly recognized component of green housing is *energy efficiency*. From 2001 through the middle of 2007, New York State Energy Research and Development Authority (NYSERDA) worked with more than 150 contractors to construct 15,000 energy-efficient homes. Although the homes cost, on average, US\$7,000 more than a conventional home, that investment paid for itself within four years through lower energy bills.<sup>54</sup> While most green building activities require more upfront planning, many green features do not add material or labor costs. A well-designed home, for example, with less square footage and an air-sealed building envelope can reduce costs through reductions in materials use, waste, water and energy, allowing for smaller heating and cooling equipment, as well as raising the quality of comfort in the finished space.<sup>55</sup>

*Single-family residences*, like all housing types, have distinct advantages and disadvantages in the context of green building. The majority of the 97,000 homes certified under voluntary green building programs are single-family homes, in part because the ENERGY STAR program has built a strong implementation platform by targeting low-rise residential buildings with one to four dwelling units. Building science research led by government organizations (including the Department of Energy’s Building America Program and the Department of Housing and Urban Development’s Partnership for Advancing Technology in Housing) has made inroads in bringing products for highly efficient residential construction to the marketplace, including insulation, higher efficiency heating and cooling equipment, high-performance windows, and energy efficient appliances and lighting, among others. Increased home size and our dependency on personal automobiles are two disadvantages of typical new housing construction. Single-family houses have a larger exposed envelope area per square foot of living space than multi-family units, but they also have a greater proportion of roof area available for producing energy from photovoltaic panels. Common components of green homes include a tight, well-insulated building envelope; highly efficient equipment, appliances and lighting; and water-conserving fixtures and landscape design.

*Multi-family housing units* promote density and have the potential to consume fewer building materials and operating energy per square foot of living space than single-family residences. Multi-family buildings frequently have greater proximity to community resources and public transportation to reduce occupant dependency on personal automobile use. Development of efficient space conditioning equipment and strategies for superior indoor air quality have lagged

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<sup>53</sup> The ten greenest cities in America. See <<http://cityguides.msn.com/citylife/greenarticle.aspx?cp-documentid=4848625&page=1>>.

<sup>54</sup> Trotta Daniel, *US struggles to build green homes*. Reuters News. See <<http://www.reuters.com/article/inDepthNews/idUSN0737751420070309?pageNumber=1>>.

<sup>55</sup> Residential Construction: Affordability. Pollution Prevention Information Center. See <<http://peakstoprairies.org/topic/subsection.cfm?hub=31&subsec=10&nav=10&CFID=8784428&CFTOKEN=80625221>>.

behind the progress made in the single-family sector, though progress is being made. While 86 percent of multi-family unit occupants are renters who may be less vested in the health, efficiency, and environmental benefits of housing than owners, professional building managers can be trained to maintain and operate multi-family buildings and properties according to green principles. Multi-family green buildings often focus on community connectivity; smaller dwelling unit size; efficient equipment, appliances and lighting; and improving indoor air quality. Until the introduction of the LEED for Homes pilot in 2005, green building standards were not applied to low-rise multi-family housing. Another factor affecting this market is that in rental units where the tenant pays utility bills there is a disincentive for the landlord to invest in energy-efficiency measures. Although single-family residences have dominated the green building market to date, multi-family housing more quickly reaps the rewards of green investment.<sup>56</sup>

**Manufactured housing**, like multi-family housing, typically requires less input of raw materials during construction due to its smaller size and the efficiencies inherent in the manufacturing process, including reduced and increasingly re-used waste and efficient manpower utilization. Great strides have been made since the early days of manufactured housing to improve the quality and energy efficiency of this housing type, though there is a need for continued progress. Of the ninety-nine manufactured-home builders that have teamed up with Energy Star, only three are committed to manufacturing a 100-percent Energy Star home, the others merely offer Energy Star options.<sup>57</sup> Green manufactured-housing emphasizes energy efficiency, reduction in waste and building materials during construction, disaster resistance through HUD-code compliance, and adaptability to different locations and climates.

### 3.4. Targets for Green Residential Buildings

Though residential green building consciousness is on the rise, there is enormous potential to expand penetration of sustainable and high performance design and construction throughout the United States. In order to enact significant environmental change, industry leaders have proposed several targets for green housing market penetration.

The *American Institute of Architects (AIA) “2030 Challenge”* proposes to achieve carbon-neutral buildings (commercial and residential) by 2030 through immediate reduction of energy use in new and renovated buildings to 50 percent of the national average, followed by a further 10 percent reduction every five years thereafter. The US Conference of Mayors unanimously adopted the 2030 Challenge in June 2006.

The US Green Building Council’s *LEED for Homes* rating system targets the top 25 percent of new homes (and low-rise multi-family housing units) nationally with best-practice environmental

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<sup>56</sup> *Party Walls* Volume 2, Issue 4 (July-August 2006). Steven Winter Associates, Inc., <[http://www.swinter.com/Services/06Tech\\_Trans/co\\_partywalls.html](http://www.swinter.com/Services/06Tech_Trans/co_partywalls.html)>.

<sup>57</sup> US Environmental Protection Agency’s Energy Star Program: <<http://www.energystar.gov/>>.

features. This theoretically represents approximately 500,000 homes/year. The USGBC announced publicly in November 2006 at its Greenbuild International Conference event its intention to have certified one million green homes under its standard by 2010, and ten million homes by 2020.

The US Department of Energy's *Building America Program* has a stated long-term goal for the year 2025 "to reduce whole house energy use in new housing by an average of 90 percent and [that of] existing housing by an average of 30 percent through a combination of production-ready energy efficiency and onsite power systems while also increasing housing affordability, durability, comfort, and health." The stated short-term goal is "to achieve an average of 50 percent whole house energy savings in new single-family housing in five climate zones by the year 2015."<sup>58</sup> Savings are relative to an established benchmark based on typical residential construction practices.

The US Department of Energy's *Building Technologies Program* Multi-Year Program Plan is to create technologies and design approaches that enable net-zero energy buildings at low incremental cost by 2025. A net-zero energy building is a residential or commercial building with greatly reduced needs for energy through efficiency gains (60 to 70 percent less than conventional practice), with the balance of energy needs supplied by renewable technologies.<sup>59</sup>

Other proposed targets for green building in the United States include *Standard 189*, a minimum sustainability performance standard being developed by ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers), the Illuminating Engineering Society of North America (IESNA), and the US Green Building Council, for commercial buildings and multi-family housing above three stories; the *Wingspread Principles*, aimed at developing a five-year action plan for the United States to take immediate, comprehensive action against global warming, developed at the first National Leadership Summit in June, 2007; and the *United Nations Environment Program's Green Building Initiative*, an effort to bring programs like LEED to areas of the globe that are not being represented in the green building construction market.

For the purposes of this paper, the authors propose that the targets listed above might be aggregated to the following immediate goals for new and renovated housing in North America, relative to existing housing stock: 50 percent reduction in energy use; 50 percent reduction in carbon emissions; 50 percent reduction in potable water consumption; 20 percent reduction in wood and raw materials consumed for housing construction; and 75 percent reduction in the amount of C&D waste sent to landfills and incinerators. The authors feel these are highly achievable short-term goals, given that a new green residence in the United States today typically

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<sup>58</sup> US Department of Energy Building America Program:  
<[http://www.eere.energy.gov/buildings/building\\_america/](http://www.eere.energy.gov/buildings/building_america/)>.

<sup>59</sup> US Department of Energy Building Technologies Program:  
<<http://www.eere.energy.gov/buildings/about/index.html>>.

outperforms the average new code-built home using existing, affordable technologies that are applicable to a variety of housing types. A comparison of the average LEED home to an average code-built home shows that the green building consumes 30 to 50 percent less energy, 30 to 50 percent less water and 5 to 25 percent less wood while producing 50 percent less waste (to landfill and incinerator) and 30 percent less stormwater runoff.<sup>60</sup>

### 3.5. Environmental Impacts of Green Housing

A recent study from the McKinsey Global Institute reports that the worldwide residential sector consumes more energy than any other sector and holds the most potential for productivity improvements.<sup>61</sup> Achieving the green residential building targets presented above would result in positive environmental impacts of the following magnitude:

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<sup>60</sup> USGBC. All the benefits of a LEED home for under a dollar a day. Powerpoint presentation.

<sup>61</sup> McKinsey Global Institute. Curbing Global Energy Demand Growth: The Energy Productivity Opportunity – Residential sector. May 2007:  
<[http://www.mckinsey.com/mgi/reports/pdfs/Curbing\\_Global\\_Energy/MGI\\_Curbing\\_Global\\_Energy\\_chapter\\_3.pdf](http://www.mckinsey.com/mgi/reports/pdfs/Curbing_Global_Energy/MGI_Curbing_Global_Energy_chapter_3.pdf)>.

**Table 3:** Comparison of Immediate Environmental Impacts from Green Housing

Environmental Impacts	All Buildings <sup>62</sup>	Residential Sector	Green Housing <sup>63</sup>
Energy Consumption, primary – percent of US consumption <sup>64</sup>	39	21	13
Electricity Consumption, primary – percent of US consumption <sup>48</sup>	71	36	22
Natural Resource Consumption:			
Water – percent of all potable water <sup>65</sup>	12.2	5	3
Raw Materials – percent of global resources <sup>66</sup>	40		
Wood – percent of US consumption <sup>67</sup>	50	40	34
US construction, renovation, and demolition (C&D) waste (million tons/yr) <sup>68</sup>	136	58	29
Carbon Dioxide (10 <sup>6</sup> metric tons/yr) <sup>48</sup>	608.1	329.8	197.9
- percent of US emissions	38	20	12
- percent of global emissions	10	5	3

## 4. Market Drivers

### Drivers to Green Residential Design and Construction

In order to reach the targets suggested above, significant market transformation must take place. A 2006 survey of architects, engineers and contractors by McGraw-Hill Construction indicated

<sup>62</sup> For energy and emission data, “all buildings” refers to commercial and residential structures; industrial buildings are excluded. Energy and emissions data is for primary energy consumption (i.e., energy consumed at the site and for electrical generation and distribution).

<sup>63</sup> Green housing impacts are based on the author’s statement of achievable green residential targets in the previous section.

<sup>64</sup> US Department of Energy, *2006 Buildings Energy Data Book*. See <<http://buildingsdatabook.eren.doe.gov/>>.

<sup>65</sup> US Geological Survey, 1995 and 2000 data.

<sup>66</sup> Lenssen and Roodman, 1995. A building revolution: How ecology and health concerns are transforming construction. Paper 124: Worldwatch Institute.

<sup>67</sup> Nebraska Energy Office. 1993. *Minimizing the Use of Lumber Products in Residential Construction*: <[http://www.neo.ne.gov/home\\_const/factsheets/min\\_use\\_lumber.htm](http://www.neo.ne.gov/home_const/factsheets/min_use_lumber.htm)>.

<sup>68</sup> US Environmental Protection Agency 1996 Construction and demolition materials estimate. <<http://www.epa.gov/epaoswer/non-hw/debris-new/basic.htm>>. HARC website: Residential construction and demolition waste. See <<http://www.harc.edu/Projects/Archive/CultivateGreen/Events/20050518>>.

that “doing the right thing” was the primary motivator for interest in green building, but **consumer demand** was the primary trigger for translating those motivations into action. Consumers, in turn, cited **energy cost increases** as the primary driver for seeking out energy-efficient green homes. Case studies have shown that the net cost of home ownership of a green home over time is lower due to savings from energy and utility bills as well as decreased maintenance costs. Both builders and consumers felt that **superior building performance** resulting from durable, healthy green homes was a significant driver to increased residential green building. Green homebuyers have reported being substantially happier with their homes than other homebuyers, and green home builders have received positive publicity and perceived competitive advantages over conventional builders.

Consumers and builders both respond to financial incentives. While **incentives** for high-performing homes have typically been energy-based and funded by utilities or tax credits, municipalities are starting to offer incentives (such as fast-track permitting) for compliance with local green home standards. Low-cost/no-cost incentives are most appealing to municipal officials. For example, Chicago’s very successful speedy permit program grants builders of LEED™ or Energy Star® building permits within six weeks, shaving two months off the typical wait. Some utility and technology-based organizations are providing grant money to support green building in affordable housing projects.

Research indicates that **codes and regulations** are another significant driver. The State of California has set a national example for sustainability through regulation with its stringent energy code. And Boulder, Colorado, and Frisco, Texas, have adopted green standards requiring compliance prior to issuance of building permits. Many other municipalities are actively investigating the adoption of mandatory green home standards. The National Association of Homebuilders announced in March 2007 a working partnership with the International Code Council to develop international green residential building standards. Government and institutional organizations including the US Army have publicly announced their intention to adopt green building practices on future residential projects.

In the commercial sector, **green certification programs** are seen as the second-largest trigger to green building (McGraw-Hill Construction, 2005). In contrast, certification programs received little recognition in 2005 as a driver in the residential green building market. Regardless, the number of green home programs started by utilities, homebuilder associations, environmental organizations, and municipal groups continues to grow. Green building programs in Denver, Austin, Wisconsin and Florida have successfully worked with large production builders in their regions. Builders operating in multiple markets or those builders who are confused by competing regional green home certification brands may find that the relatively new national certification programs, NAHB Model Green Home Building Guidelines and LEED for Homes, are better able to serve their needs. Though LEED for Homes is still in its Pilot phase USGBC reports that interest and demand in the program has exceeded their initial expectations.

The **lending industry** has an important role to play in promoting green home building and, while the USGBC has been advocating green Mortgage-Backed Securities (MBS) for years, institutions have been slow to embrace this concept of packaged mortgages for buildings that meet specific energy use and environmental benchmarks. Some financial institutions, such as

Bank of America, Citibank and Wachovia, are beginning to offer creative incentive products for green building, including lower-rate mortgages. The Federal Housing Administration (FHA) now offers a program for borrowers to purchase new energy-efficient homes or to make upgrades that improve the efficiency of existing homes by including additional costs of green features into the mortgages when they can provide evidence that the improvements will lead to energy savings. Fannie Mae, too, offers special mortgages for environmentally sound, affordable housing, providing energy-efficient mortgages that qualify borrowers for a higher amount if they purchase a home with energy-conserving features, acknowledging that potential energy savings will compensate for higher house payments. Fannie Mae also offers smart-commute mortgages: borrowers who live near public transportation qualify for a larger mortgage on the basis that the homebuyer will save money on transportation expenses.

## 5. Market Barriers

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### Barriers to Green Residential Design and Construction

The most significant barrier to residential green building most cited by industry professionals and the public is *higher perceived first cost*. This perception is particularly challenging to dispel because broad-based research on the economics of residential green buildings is presently very limited. A greater body of data is available for commercial office buildings, where the estimated increased first project cost typically falls in the range of two to four percent. The added cost of incorporating green building features into residential projects depends largely on local factors such as climate, local building customs, and labor skill levels. Members of the NAHB actively involved in green building reported increases as low as two to five percent, with an average project cost increase of 8.7 percent. In contrast, NAHB members who were not actively involved in green building estimated that the additional cost to their projects would be an average 11.1 percent to build green.

Another barrier to residential green building is a *lack of knowledge*, including biases in perception, apathy, and lack of understanding about benefits of green residential building. This lack of knowledge appears pervasive at all levels of the industry, including lenders, realtors, builders, general contractors, home inspectors, buyers, suppliers, and regulatory officials.

The third major challenge to green residential design and construction is the *lack of widely used standards* to consistently define criteria for a “green” product, service, or building. While some standards have emerged for specific product categories (such as the Carpet and Rug Institute’s Green Label Plus criteria for chemical content or the Green Seal limits for volatile organic compounds in paints), builders and consumers cite concerns over “greenwashing” as an obstacle to evaluating products or residences marketed as green. With over 80 different regional green home rating systems operating in the United States, some builders imply that confusion over which standard to follow, or the difficulty in adhering to different local programs in multiple markets, is a deterrent from undertaking green building.

A fourth barrier to more widespread green housing design and construction is the *scarcity of products and expertise*. While environmentally preferable products and high performance residential equipment and systems are increasingly available at the national level, many markets are still underserved by manufacturers of green products and by industry professionals knowledgeable in green means and methods. Even where products or personnel are available, the lead times can be extraordinary, as demand for green outstrips the supply capacity.

## 6. Recommendations

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In order to achieve the market transformation necessary to meet targets like the 2030 Challenge, the three governments of North America might undertake the following actions to capitalize on existing market drivers and overcome barriers to green residential building:

### 6.1. Develop and Implement a Common Vision

By having a common vision among the three NAFTA countries, Canada, Mexico and the US can bring to bear increased resources to empower green homebuilding in their respective countries: shared information, mutual support, joint communications, and other strategies can further the movement. When viewed as a single sustainability target, North America represents a market of 400 million people,<sup>69</sup> 150 million existing housing units, and 3 million new housing starts each year.<sup>70</sup> Despite regional, cultural or social differences among the three countries, North America can be considered a single market for green concepts. In the United States housing market for example, numerous different regional, construction types, and green building practices are a single market for the LEED for Homes program.

One of the first steps to develop a common vision is to *gather, share, and compare information* from all three countries on the state of green building in order to better understand market drivers, barriers, and potential environmental impacts from market transformation. Potential data sources include builders operating in all three countries (production builders and hotel/motel builders may be particularly valuable resources), housing researchers and innovators, and green building advocacy groups. The authors recommend regular correspondence and periodic physical review of accumulated information and data concerning building science and building products, advances in recycling and re-use of materials.

*Documenting and sharing commonalities* in green building strategies among the three North American countries will enhance the global effort, though each region will naturally approach

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<sup>69</sup> Population by country, index: <<http://www.geographic.org/people/people.html>>.

<sup>70</sup> Mexico prepares to meet future housing demands. 2004. Realtor.org. See <[http://www.realtor.org/IntUpdt.nsf/Pages/Mexico\\_Pre pares](http://www.realtor.org/IntUpdt.nsf/Pages/Mexico_Pre pares)>.



green building in a unique manner. Mexico may have more multi-family housing and Canada may have more cold-weather construction, but housing in all three countries needs to achieve healthy interiors, water conservation, energy conservation, reduced materials consumption, etc. Adopting parallel initiatives in all three countries will help to drive green building practices.

The three countries of North America can support the creation and adoption of *international criteria and standards* for green building as well as for energy performance, with provisions for climate and culture-specific variations but with a common goal for positively impacting the environment. Just as LEED and other standards have been able to accommodate the wide variations in housing needs across the United States, international standards could be crafted to accommodate housing across all three countries. As illustrated by the more mature commercial green building industry, green standards and certifications are likely to become strong drivers for the adoption of green practices, including not only design and construction but also the practices for financing, appraisals, insurance, and zoning.

Consumers list energy savings as a top priority, yet a vast quantity of household energy savings potential remains untapped. A 2007 McKinsey Global Institute study concluded that projected electricity consumption in residential buildings in the United States in 2020 could be reduced by more than a third if compact fluorescent light bulbs and an array of other high-efficiency options including water heaters, kitchen appliances, room-insulation materials and standby power were adopted across the nation.<sup>71</sup> *Federal incentives and support* for resource-efficient residential appliances, mechanical equipment, and fixtures are nothing new and, in this case, McKinsey researchers predict that the energy savings from utilizing these basic technologies would equal the energy production from 110 new 600-megawatt coal-fired power plants. The authors recommend that the governments of all three countries revisit existing programs in light of the changing social and political climate and raise the bar to push energy savings to the next level.

If there is one Achilles heel facing the green housing industry, it is the need to verify the performance that is promised. The authors believe that green design and construction practices actually result in better energy savings, occupant and worker health, durability and other performance attributes, but such attributes need to be conclusively and continually verified to make these claims credible. *Performance monitoring and testing protocols* in Canada, Mexico, and the United States for new and renovated residential buildings is necessary to confirm performance assumptions and provide contextual data on the effectiveness of green building practices. Collected data will provide feedback loops for continual improvements in the common vision for sustainable housing.

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<sup>71</sup> Steve Lohr. Energy standards needed, report says. *The New York Times*. 17 May 2007. <<http://www.nytimes.com/2007/05/17/business/17energy.html>>.

## 6.2. Leverage Shared Resources and Information

The public and private sectors of North America can promote *international trade* in housing and construction materials and equipment, particularly environmentally preferable products and proven-yet-underutilized technologies. Consider implementing a carbon-emissions trading program similar to the European Union's greenhouse gas emissions trading program: a cap-and-trade system that would penalize polluters and reward companies investing in clean power. Companies that achieve dramatic reductions in carbon emissions would sell credits to producers that exceed the limit, providing a marketable business for the seller and allowing the violators to buy time while developing an effective solution to lower emissions.<sup>72</sup> Governments may also implement tax and/or rebate incentives for the trading of environmentally preferable products.

Identifying residential building products that are rapidly renewable, locally harvested, low-emitting, or recycled can be a daunting task. The authors recommend that the three countries of North America support the development of an *eco-labeling program* to aid consumers and manufacturers. Specific green labeling is available for some types of products, including paints (Green Seal) and carpets (Carpet and Rug Institute's Green Label Plus). The ENERGY STAR program labels a host of products for energy efficiency, including appliances, lighting, mechanical equipment, and roofing. But unlike Thailand, Germany, Japan and a host of other countries, Canada, Mexico, and the United States lack a consistent green label. A labeling program of this sort would enable consumers to quickly identify environmentally preferable products, and product manufacturers could potentially capture a new market share. The US Department of Agriculture introduced its "USDA Organic" label to assure consumers that foods were produced without antibiotics, hormones, pesticides, irradiation or bioengineering. The effort to meet consumer demand for healthy and safe product alternatives is paying off: sales of organic-labeled foods increased by 22 percent from 2005 to 2006.<sup>73</sup>

On a macro scale, misconceptions about sustainable solutions cloud the ability of decision makers, developers, and consumers to make confident choices. Clean coal, carbon sequestration, nuclear power, and biofuels have all been presented as options for solving environmental crises in North America, but each of these technologies carries significant risk as well as benefit. The authors encourage the governments of Canada, the United States and Mexico to take immediate action to improve human and environmental health by investing in *proven but underutilized* solutions for green housing, such as resource conservation and renewable energy.

The green housing sectors of North America would greatly benefit from pursuing *joint research opportunities* to leverage expertise and resources in all three countries and to avoid duplication of effort. The collaboration of industry, national laboratories, private research companies, and research universities in Canada, Mexico and the United States represents significant potential to promote and perfect green building materials and methods. Potential research topics include

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<sup>72</sup> Europe's carbon trading market: National Public Radio broadcast.

<sup>73</sup> US organic sales show substantial growth. Organic Trade Association, 2007.  
<[http://www.organicnewsroom.com/2007/05/us\\_organic\\_sales\\_show\\_substant\\_1.html](http://www.organicnewsroom.com/2007/05/us_organic_sales_show_substant_1.html)>.

building science, occupancy evaluations/performance data, materials reduction/reuse/recycling, life-cycle analysis and energy analysis tools, and net zero-energy buildings. Most related research today is aimed at energy efficiency in buildings and renewable energy technologies, with very little emphasis on other aspects of green buildings. A report released in March 2007 by the USGBC cited only 0.2 percent of the US federally funded research budget targets green building.<sup>74</sup> When weighed in the context of the potential benefit to global society, this percentage seems disproportionately low. Green building research dollars equal only 0.02 percent of the estimated \$1 trillion value of annual US buildings construction, and the construction industry reinvests only 0.6 percent of sales back into research—a figure significantly lower than the average for other US industries or private sector construction research investments in other countries.<sup>75</sup> In order to meet the targets suggested for lowering carbon emissions and avoiding serious environmental consequences, industry and government throughout North America needs to invest willingly in the tools necessary to bring green housing into the mainstream.

Furthermore, the authors encourage government, industry, educational and advocacy groups to support the *dissemination of research and training information* to a broad North American audience to further industry professionals' and consumers' knowledge of green buildings. Though each country has conducted informative research on advanced solutions for sustainable, affordable housing, there has traditionally been a breakdown in transferring findings to the broader audience of design and building professionals (and even consumers). Green housing has entered mainstream media in Canada and the United States, but consumers and builders in many markets are still frustrated by a lack of access to sustainable design and construction expertise. The authors feel strongly that this research and development should be made easily accessible. Education and research facilities throughout North America can play a critical role in developing and distributing green building information throughout the industrial and public sectors.

Government and industry partners can move the residential market toward a more sustainable future by supporting the *current green housing organizations* and initiatives that are already promoting sustainable and affordable development in Canada, Mexico, and the United States, and like the Green Building Councils and organizations that develop standards and criteria for green building products or equipment. For example, the governments might implement a council (perhaps as a subset of the CEC) to which national organizations can report. Furthermore, such a council can help to facilitate relationships between supporters of green building and realtors, appraisers, financial institutions, and policy makers in all three countries to accelerate green housing market penetration. For example, realtors, architects, attorneys, and builders who are practicing their disciplines in green building might be allowed to obtain necessary permits across countries more easily.

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<sup>74</sup> USGBC finds research underfunded. *Environmental Building News*, June 2007. <<http://www.buildinggreen.com/articles/IssueTOC.cfm?Volume=16&Issue=6>>.

<sup>75</sup> Department of Energy. *2006 DOE Buildings Energy Data Book*, 19 February 2007. <<http://buildingsdatabook.eren.doe.gov/>>.