Improving Conditions for Green Building Construction in North America

Enhancing Capabilities of the Green Workforce

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List of Acronyms

ACG	AABC Commissioning Group
ARRA	American Reinvestment and Recovery Act
BIM	building information modeling
CEC	Commission for Environmental Cooperation
EEBA	Energy and Environmental Building Alliance
HVAC	heating, ventilation, and air-conditioning
IAPMO	International Association of Plumbing and Mechanical Officials
IPCC	Intergovernmental Panel on Climate Change
IREC	Interstate Renewable Energy Council
ITESM	*Instituto Tecnológico y de Estudios Superiores de Monterrey* (Monterrey Institute of Technology and Advanced Studies—"Monterrey Tech," "*Tecnológico de Monterrey*")
LCA	life-cycle assessment
POE	post-occupancy evaluation
SAIT	Southern Alberta Institute of Technology
SBA	Sustainable Building Advisor

Abstract

Among other factors, increasing uptake of green-building construction in North America requires access to financial capital, enabling policies, and a skilled workforce. As part of the report series *Improving Conditions for Green Building Construction in North America*, this report reviews education and training opportunities throughout North America and compares those opportunities to the skills and capabilities that are needed now, or will be needed over the next decade, in ten vital workforce sectors: builders, building trades, design professionals, building operators and managers, owners and developers, real estate and finance sector, manufacturers, municipal and other government officials, specialty consultants, and occupants. The report also identifies characteristics that make education and training programs successful, points out gaps between the educational offerings and anticipated needs in the industry, and makes recommendations for disseminating these best practices along with steps for addressing those gaps. In addition to these industry-specific education and training needs, the report emphasizes the value of educating those who can drive demand for green building, especially corporate clients in the United States and Canada, and government officials in Mexico.

Executive Summary

Recognizing that green building requires specialized skills and capabilities on the part of many actors in the building industry, this report reviews education and training opportunities throughout North America and compares those opportunities to the skills and capabilities that are needed now, or are likely to be needed over the next decade. It also identifies gaps between the educational offerings and anticipated needs in the industry, and makes recommendations for bridging those gaps.

All workforce sectors need specific technical skills, such as the ability to work with certain tools or install certain systems, as well as interpersonal skills—the ability to communicate and collaborate effectively. Beyond skills, however, all parties to a green building project will be most effective if they also embrace an ecological mindset of interdependence and interconnectivity and shift their thinking from the conventional, sequential hand-off paradigm of design and construction.

Successful education and training programs typically have one or more of the following characteristics:

- Knowledgeable, charismatic trainers with experience in the field
- Peer-to-peer mentoring
- Online education that is accessible whenever the students can make time for it
- Short-format instructional videos
- A focus on the “why” of green approaches in addition to the “what”

The recommendations include specific suggestions for disseminating these best practices, along with steps for addressing the following gaps:

- Ecological mindset and awareness
- Soft-skills training and mentoring
- Financial benefits and evaluation
- Training in specific technical fields
- Cross-disciplinary education and training

In addition to these industry-specific education and training needs, the report points out the value of educating those who can drive demand for green building, especially corporate clients in the United States and Canada, and government officials in Mexico.

Foreword

Green building practices have the potential to save energy, save money, and improve the quality of human habitat across North America. They can also contribute to water conservation, more efficient use of raw materials, and ecosystem health around the globe. The Intergovernmental Panel on Climate Change (IPCC) singled out the building sector as having the most cost-effective opportunities for reducing carbon emissions—in fact, many building-related opportunities are cost-neutral, or even cost-positive, to the building owner.

These benefits have made green building practices the fastest-growing trend in the building industry, but they still represent only a fraction of new construction, and the enormous stock of existing buildings has barely been touched at all. Even projects that are pursuing green strategies rarely go as far as they could, settling for marginal improvements in energy efficiency or introductory green certification when much more could be readily achieved.

In accordance with its mission of improving the natural environment by fostering collaboration among the three North American countries, the Commission for Environmental Cooperation (CEC) is exploring the barriers to more-widespread and deeper adoption of green building practices, and is identifying ways to overcome those barriers.

This work is guided by the Trilateral Green Building Construction Task Force, which includes members from Canada, Mexico, and the United States. Charged with following up on the issues raised in CEC's authoritative 2008 report, *Green Building in North America: Opportunities and Challenges*, the task force has led the Improving Conditions for Green Building Construction in North America project as part of the Cooperative Work Plan for 2011–2012.

This initiative seeks to identify opportunities and drive changes needed to support the construction of green buildings and green renovation of existing buildings in North America. As a central component of its work, the task force commissioned three reports to guide both public and private sector efforts in critical areas.

Covering financial mechanisms, education and training programs, and local government initiatives, the three reports identify challenges and recommend solutions for leaders in each of these areas. Each report addresses the particular needs and opportunities of a specific area, while complementing the others.

Financing is the lifeblood of any building project. Workforce skills and capabilities are essential to realizing the project. And local government policies are needed to raise awareness of the benefits of green building, encourage the creation of green projects, and represent the collective interest of each community in a built environment that supports the health and well-being of the public.

While the findings and recommendations of each report are noteworthy individually, collectively they point to a huge opportunity in the green building and public policy sector. As science fiction author William Gibson pointed out in *The Economist* in 2003, "The future is already here—it's just not evenly distributed." This observation is particularly apt in the realm of green building, where some cities and regions are implementing programs and seeing technology and design innovations that are well ahead of the rest of the North American continent. As a result, rather than inventing new approaches from scratch, we now have successful precedents to emulate and adapt—those examples are highlighted throughout these reports.

The three reports—one of which you are now reading—are further enhanced by several related initiatives from the CEC: a comprehensive online resource repository that provides, in one place, a library of relevant source materials; a guide to green building rating systems and programs in North America; and support for Mexico's adoption of the Energy Star benchmarking methodology.

This report, in conjunction with its two siblings and the other related projects, constitutes an important resource that financial organizations, local governments, and educational institutions can use to create their own effective green building initiatives. By connecting the specific interests of building owners and occupants with the common interests of communities, countries, and a whole continent, the CEC is bringing green building to the forefront as a solution we all can use.

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Introduction

This report was commissioned to answer the question: What current education and training opportunities exist in North America and how well do they fulfill current and future (five-year, ten-year) needs? The report looks at the responsibilities and needs of workforce sectors involved in green building and then identifies relevant training opportunities—or the lack thereof—and makes recommendations for filling educational gaps.

The report begins with a high-level assessment of the state of green-building practice in North America, followed by a more detailed look at the skills and capabilities needed within each workforce sector to effectively design, build, and operate green buildings. It continues with an assessment of the education and training offerings, and the gaps in those offerings; the needs and opportunities of Mexico are distinct from those in the US and Canada and are therefore described separately. The report concludes with a series of specific recommendations on how gaps can be addressed and education and training opportunities nurtured to best support the workforce needs of the next decade.

Chapter 1: Green Building in North America

By most measures, green building as a movement and as a practice has arrived in North America. It's no longer a fringe activity—it has become part of the mainstream. In a 2011 survey of the construction industry, McGraw-Hill found that 88 percent of respondents reported working on at least some green projects (McGraw-Hill 2012, 12).

What Is Green Building?

What exactly it is that has arrived, however, is a different issue. Throughout the US and, to a lesser extent, in Canada and Mexico, green building is defined largely based on the framework of the LEED (Leadership in Energy and Environmental Design) rating system. McGraw-Hill's research includes projects "built to LEED or another recognized green building standard" or that are energy- and water-efficient and address indoor air quality and resource conservation (McGraw-Hill 2012, 11). That report doesn't specify how researchers verify the extent to which projects are actually engaging with those goals, much less accomplishing them.

Green building as defined by LEED is becoming mainstream, but this addressing-the-things-we-associate-with-green definition is a far cry from the core purpose of green building, which champions describe as transforming the building industry into a force for environmental protection and restoration (BuildingGreen 2013). Global indicators, such as carbon levels in the atmosphere, biodiversity, dispersion of toxic substances, and ocean health, suggest that very little protection is occurring (Bapna 2012). On the regional and local scale, indicators are more mixed, with air quality problems, deforestation, desertification, and many other problems running rampant in some areas, while environmental clean-up and restoration are improving habitat and human health in others.

While green-building efforts may be playing a role in local success stories, many are still contributing more to the problem than to the solution—witness the many so-called green buildings that contribute to sprawl by locating in auto-dependent locations, or air-seal and insulate walls without serious attention to moisture-management, leading to microbial growth and its associated health and durability problems.

Even when construction of green buildings is demonstrably moving in the right direction, it is still falling short of even making a dent in the global problems we face (Watson 2011, 38). Studies suggest that LEED projects achieve, on average, a 24–33 percent reduction in energy use compared with average building stock (Turner and Frankel 2008, 2) but that still leaves the much larger fraction of non-green construction creating "energy-guzzling" buildings, not to mention the much larger inventory of existing buildings that have not been retrofitted to achieve "green" performance.

Green-building construction is, on the whole, attending to the right issues—but to justify its existence as a movement, green building has to do much better, and at a much larger scale.

There are isolated "points of light" in the green movement that show this can be done. The handful of buildings pursuing Living Building Challenge certification, the net-zero-energy buildings that are also appropriately sited, the deep-energy retrofits of existing buildings, and communities with shared resources—all these are indicators that the building industry *can* become a force for ecological improvement in the world.

Inevitably, this is the direction that the building industry and our society as a whole must be moving, and we can see the shift happening—more rapidly in some places, less so in others. As Bill Gibson aptly said, "The future is already here—it's just not very evenly distributed" (Gibson 2009).

Regionally, we see some parts of the US and Canada leading the way, with advanced policies and projects exemplifying this change. The Cascadia Region of British Columbia, Washington, and Oregon, extending down to the San Francisco Bay area, is a clear leader in this regard. Other regions are just getting up to speed with the standard approach to green building from the last decade. In Mexico, those segments of the construction market that have moved into industrialized, high-tech construction have yet to adopt green in any significant way, while the parts of the country that are still building in more traditional styles and methods are often lower-impact than other parts of North America by default. It is notable that per-capita energy consumption in Mexico is significantly lower than in the US and Canada, at least in part due to lesser reliance on air-conditioning, which in turn is due to less access to expensive technology rather than to pursuit of environmental goals.

Canada/US

Green building is widely understood and appreciated in Canada and the US, and the design and construction communities have come a long way in gaining the expertise needed to deliver green building as commonly defined. In spite of this widespread awareness and growing adoption, green building suffers from the perception that it costs more and may not deliver on the promised benefits (World Green Building Council 2013).

Green building practice is most advanced in urban areas generally, and in regions of Canada and the US that tend to have the greatest environmental awareness—especially the Pacific coast south of Alaska, and the Northeastern US.

Concerns about cost and the perceived disconnection between promise and building performance are causing some players in the mainstream building industry to hesitate about moving in a green direction. Both of these are problems that can largely be addressed by improving the skills and capabilities of industry players. The cost of delivering green buildings goes down as owners and their design and construction teams gain experience and skills, learning the most cost-effective ways of achieving specific goals.

Better informed teams also tend to be more successful in delivering projects that perform in line with their design aspirations, as they can better identify technologies that work and know how to ensure that

commissioning and hand-off are implemented well. The conventional design/bid/build delivery model for real estate institutionalizes a separation of functions that works against this goal. An alternative design/build/operate model, in which one entity is responsible for all those functions could help educate both trades and designers on a truly integrated new-building delivery process with a stronger connection between intentions and actual performance (J. Westeinde interview 2012).

Mexico

Industry demand for green buildings in Mexico is still very low.

Social well-being, environmental commitment, and long-term energy efficiency (and thus economic efficiency) are not high priorities for building owners, and initial price is the primary industry driver. This nearly exclusive focus on first costs remains a barrier to high performance.

The lack of attention to green building is a concern, because local and regional problems such as water shortages, energy shortages, pollution, and vehicular gridlock are expected to become very serious in the next five to ten years, where they are not already (J. Lobatón interview 2012).

It's likely that widespread regulatory requirements and subsidies will be needed to force the Mexican building industry to adopt green practices (P. Cristerna and V. Pérez interviews 2012). So far, the most successful case of an association leading a positive change in the industry is the "Hipoteca Verde" (Green Mortgage) by national mortgage lender Infonavit. This program led to booming demand for basic green construction products such as insulating panels, heat-reflective paint, and solar water-heating systems, and five million green mortgages were initiated during the last six years.

In Mexico, people who design, develop and build are the ones responsible for changing the industry. Preparing the workforce with much-needed practice and knowledge will require enforced government regulations for the private sector to follow.

Chapter 2: Skills and Capabilities Needed in the Industry

In this section we describe skills and capabilities—and the mindset—needed generally for all workforce sectors, followed by a more specific analysis by sector. While the skills needed are the same for both current professionals pursuing continuing education and for new students and trainees entering the workforce, the opportunities and modalities used to teach them may be quite different.

Needs across All the Sectors

To effectively deliver the kinds of green building that can become a force for positive change at global, regional and local scales, all workforce sectors need new skills that are both technical and interpersonal in nature.

Following the Leaders

The building industry will evolve over the next decade, adapting to changing social, ecological and financial conditions, adopting new technologies and, hopefully, embracing the need to reduce the ecological footprint of the built environment. As it evolves, more areas of North America will need the kinds of skills and capabilities that are currently in demand in areas that are farther along in this evolution, such as British Columbia, where people with the necessary skills are already hard to find: "Qualified and experienced engineers and technicians involved in the design, manufacturing, installation, and maintenance of energy-efficient technology and green building products and systems continue to be the most difficult positions to staff. Sourcing trades and construction workers skilled in the sequencing and application of advanced green building practices also presents challenges" (Shorthouse 2012, 1).

Technical and Interpersonal Skills

The literature and industry players describe a range of skills and capabilities that are needed now and are likely to be needed in the future. The knowledge and skills described across all the workforce sectors can broadly be delineated as "hard" and "soft" skills: either "technical"—the ability to work with certain tools or install certain systems—or "interpersonal"—the ability to communicate and collaborate effectively. We elaborate on these needs below as they relate to each workforce sector.

Beyond Skills: Looking at Mindset and Paradigms

Some of our sources focus beyond the realm of skills and capabilities themselves, pointing out that to really improve the synergy between built and natural environments our society as a whole, and especially those responsible for creating and managing the built environment, need a whole new mindset under which to operate. As long as we continue to operate from within the paradigm of our current industrialized society, we are unlikely to resolve the challenges of continued human occupation

of this planet. Any transition to a sustainable future will require both cultural and technological advances (Cole 2011); arguably, the cultural advances are far more necessary—and lacking—than the technological ones (A. Edminster interview 2012). For this mindset shift to disseminate broadly, economic structures that currently encourage the externalization of costs will also have to change.

To some extent this can be seen as an extension of the interpersonal skills, but in a way that moves beyond the anthropocentric view and includes non-human inhabitants of our planet as critical stakeholders. How can we learn to "listen to" and collaborate with natural systems, just as we have to get better at collaborating with each other?

The broader framing of the decision-making processes of stakeholders within a sustainability debate calls for a paradigm shift that acknowledges the world as a complex dynamic system and is founded on holistic and flexible strategies. While such a fundamental shift may take time to unfold, a whole-systems view would seem a necessary and valuable means to better understanding the roles and relationships of stakeholders (Cole 2011).

But this transformational need goes beyond the realm of skills as well, as it involves a shift in understanding of our place as people in the world—moving from a focus on each of us as independent actors to a focus on our place as integral components of a larger whole (J. Cloud interview). This shift in mindset can be taught explicitly, up to point. It is also useful as a framework for considering *how* we teach, because it's also about connecting with core values and an inherent desire for meaning that many people experience. Drawing on those elements can make the learning, even of specific skills, much more meaningful and effective—we elaborate on this idea below, under Recommendations.

Supply and Demand

There is a delicate balance between supply and demand for specialized skills. Just as it is a problem when demand for a certain capability can't be met due to workforce limitations, it is important for training programs and skills not to get ahead of market demand for those skills (G. Trump interview 2012). For example, the 2009 American Reinvestment and Recovery Act (ARRA) in the US allocated an unprecedented amount of money for training people to do weatherization (also known as "home performance") work on existing homes, but many of those trained have been unable to capitalize on their new skills. Creating that demand and, more generally, the context in which much of this green building work can occur is the focus of several related tasks under the current Commission for Environmental Cooperation project, Improving Conditions for Green Building Construction in North America.

Needs by Workforce Sector

The general needs described above play out differently for each workforce sector. We start each section below with a summary of the basic interests and responsibilities of each of the following sectors, followed by the skills and capabilities it will need in the emerging green building realm.

Sectors:

1. Builders	2. Building Trades	3. Design Professionals	4. Building Operators and Managers	5. Owners and Developers
6. Real Estate and Finance	7. Manufacturers	8. Municipal and Other Government Officials	9. Specialty Consultants	10. Occupants

1. Builders

Included in this category are the following:

- Construction managers
- General contractors
- Home builders

Conventional interests and responsibilities:

During the process of completing a design and beginning construction, contractors and builders are the hub of a network of players which includes the owner, the subcontractors ("subs"), and designers, building officials and many others who provide input along the way.

In a typical construction procurement process, the general contractor (GC) bids on a project and is responsible for completing the construction for the agreed-upon price. Changes made to the design during construction may be classified as "change orders," for which the contractor can charge extra.

Homebuilders may be working for a specific client on a design prepared by the homebuilders themselves or by a third-party designer, or they may be building a home "on spec" in the hopes of selling it during or after construction.

Contractors are liable for anything that might go wrong on the job, so they focus on minimizing risk while completing the project as quickly and inexpensively as possible to maximize their profit.

Green building technical skills:

As the hub of a complex network of players, general contractors and builders have to keep up with new technologies—not usually to build or install them directly, but to manage the bids and contracts with the subs who do that work. Their most challenging role on a green project is to understand the integration and interaction of systems, so they can make sure that their bids account for the labor involved when the process includes elements with which they are less experienced. They also have to manage the sequencing and integration of all the services, including steps like commissioning, which are more specific to green projects. This is not just a sequencing issue—contractors and their crews have to understand the commissioning process and how to support the work of the commissioning authority for that process, in order to proceed effectively. These goals are best achieved when the contractors are well-versed in green building techniques and technologies, so that they coordinate all the steps effectively.

Products change all the time. Basic building materials don't change as fast, but the ways in which they are used, and evaluated for use in a green project, are evolving rapidly. Both designers and builders have to get up to speed on new-material selection criteria (K. Ritchie interview 2012).

Interpersonal skills:

Contractors—especially the preconstruction professionals who prepare bids and shop drawings—can be invaluable on a project team if they are brought in early to participate in the design process. To serve the team and the project most effectively, however, they have to fully understand integrated design and contribute their expertise in a way that enables achievement of the project's goals in the most cost-effective way, as opposed to merely objecting to approaches that are novel or innovative. This involvement, when allowed in the construction procurement process, will also help ensure that they understand the goals and rationale for design choices and can support those through the construction process (M. Gentile interview 2012).

2. Building Trades

A wide range of trades might be engaged on a construction project. Some of the key trades represented in our interview process were the following:

- Carpenters
- Electricians
- Plumbers
- Roofers
- Photovoltaic (PV) installers
- Drywall installers
- Insulation and air-sealing contractors
- Heating, ventilation, and air-conditioning (HVAC) contractors

Conventional interests and responsibilities:

Construction tradespeople are the ones most directly involved with actually creating, assembling and installing the elements that become a building. Traditionally, they are concerned with efficiency of their workflow, safety on the job, and, of course, wages. Their responsibilities relate to quality and timeliness—even though the general contractor is responsible for overall coordination, tradespeople have to coordinate their work with many others to allow the project as a whole to progress effectively.

Green building technical skills:

Trades need more training in general, especially in green approaches and materials (R. Milich, B. Watt, S. Pope interviews 2012), and on how their particular work relates to that of other trades. Residential construction, in particular, is an area in which tradespeople are often underskilled to perform the increasingly sophisticated tasks asked of them. Energy retrofits done poorly are likely to risk "green backlash" if the expected energy savings are not achieved or, even worse, buildings are damaged by moisture that becomes trapped due to added insulation and air sealing (J. Lstiburek interview 2012).

Some sources argue that it is unrealistic to expect tradespeople to understand and install properly the myriad of interconnected systems that make up larger commercial buildings, in particular, and that manufacturers should do more in terms of systems integration, prefabrication, and even ongoing responsibility for the performance of their systems (V. Loftness interview 2012).

Until that happens, there will be lots of interfacing and testing to do, and the trades should be doing much of that. So they have to learn performance testing skills, such as using blower doors and thermography. In some areas, leading contractors (e.g., window wall and curtainwall installers, and air-sealing tradespeople) are beginning to pre-test their work, making sure their systems work before the commissioning agent or building inspector arrives to check (V. Loftness interview 2012).

One of the many specific areas of expertise that also challenges trades because it crosses traditional trade roles on a job site is the installation of PV systems on rooftops, which demands new knowledge and capabilities from both electricians and roofers. Solar thermal systems place similar demands on plumbers.

Interpersonal skills:

In the emerging green-building field, contractors will need to adapt continually to new technologies and systems, so their training needs to focus not just on acquiring new specific technical skills, but on gaining the ability to rapidly learn and adapt as the demands change.

"Integrated construction" and "integrated design" require more diverse knowledge on the part of contractors and subcontractors, especially on green-building features (D. Satnik, J. Westeinde, M. Gentile interviews 2012). At a minimum, tradespeople must ensure that a project's green performance

goals are not compromised. Ideally, they will understand those goals well enough (this is most likely if they are integrated into the project at an early stage) and apply their valuable experience in the specifics of how certain materials or systems are installed to propose better ways of designing and building the systems for which they are responsible (Y. Wright interview 2012).

Green construction typically requires more collaboration, coordination and communications among different trades. To succeed at those tasks, many in the trades would benefit from project management and facilitation training. This is particularly important in small commercial buildings and single-family housing, where currently contractors often have little formal training in these skills.

3. Design Professionals

We focused on the following design professionals in our interview process:

- Architects
- Engineers
    - mechanical
    - civil
    - structural
    - electrical
- Interior designers
- Landscape architects
- Planners
- Specification writers
- Commissioning authorities

Conventional interests and responsibilities:

These skilled professionals care about their reputation for designing successful buildings and systems. Those whose work is more visible—architects, landscape architects, interior designers—also have an interest in the impression they make on the public and are concerned about professional liability, earning sufficient fees to do creative work, and how to coordinate their work with the rest of the project team.

How their responsibilities are defined depends on the method used for building procurement. In a conventional design-bid-build arrangement, design professionals are responsible for producing designs that meet building codes and the client's requirements, and for documenting designs in a set of construction documents that become part of a legal contract between the owner and the contractor to build the project. One consequence of this procurement approach is that different actors have different drivers: contractors are incented to maximize profits by building as cheaply as possible, or to claim extras at any opportunity, while design professionals are loath to admit any design imperfections, due to liability concerns. As a result, design/bid/build contracts frequently foster adversarial relationships that can impair operating performance.

Alternative design/build and integrated project delivery arrangements can allow for more-flexible interactions between design and construction professionals and reduce the effects of such split incentives.

Alternative procurement approaches typically include a smaller number of actors, and integrated development process roles, which in some cases include building operations and maintenance. While these approaches could result in better, greener buildings, there is little research as yet on their real-world performance. They tend to require more unconventional financing, contract creation and team management efforts and skills.

Green building technical skills:

On green or high-performance projects, designers are expected to know about—and, ideally, have experience with—a wide range of new and emerging technologies, evaluation/certification programs, and even material selection criteria. The following are examples of the type of knowledge that is increasingly expected in the area of materials selection:

1. Health/chemistry: understanding where there are going to be trade-offs, because it's not always possible to find alternatives that perform well.
2. Responsible sourcing: including topics such as sustainable mining, Forest Stewardship Council (FSC)–certified wood, and legally harvested wood.
3. Carbon footprint of products: familiarity with environmental life-cycle assessment (LCA) and the time value of carbon. Not just to prefer "carpet A" to "carpet B," but to drive manufacturers to work to reduce the ecological footprints of the products. That focus needs to be part of their mindset (K. Ritchie interview 2012).

It's not always clear how much of that information designers are expected to master themselves, as opposed to just gain enough familiarity with in order to engage experts as needed for full implementation (7group and Reed 2009). In general, firms that have more green experience tend to have more of that information at hand, whereas those newer to green building typically need to outsource it.

Regardless of the green agenda, designers are also constantly faced with new and evolving design and collaboration tools, most notably building information modeling (BIM) software. Using such software to support green performance expectations adds another layer of functionality and complexity to master (K. Ritchie interview).

Energy modeling is the most advanced of these green-related performance analysis functions, and at every level the requirements and expectations are evolving and changing rapidly (I. Theaker, G. Shymko, S. Pope interviews 2012). Sophisticated modeling tools can now simulate aspects of a design, such as radiant comfort, underground heat transfer, and natural ventilation, that were very challenging to model before. Rapid early-design-phase modeling is becoming accessible even to less technically

inclined architects—but with a strong risk of poor results due to poor understanding of the limitations of the data and software used.

Related to energy modeling is lighting design, which is increasingly supplemented by daylight modeling to reduce artificial light use. Good use of daylight in schools, offices, stores and many other project types is a huge opportunity for improving occupant well-being and performance and saving energy, but these benefits are easily undermined if the design and implementation are not done very well (Ander 2012).

Another major and relatively new area of practice is building commissioning, which has expanded over the last dozen years from use for only especially complicated and mission-critical facilities to high-performance buildings of all types. Commissioning has also evolved from something akin to "close-out testing" to a more holistic review that begins during design, and is widely considered invaluable as a way of ensuring that the owner's project requirements and the design team's intentions are reflected in the project as built, and in facilitating good information transfer in the hand-off of a facility to the building managers. Just in the last few years the scope of that practice has expanded to include, on some projects, building-envelope commissioning (Melton 2012). For existing buildings, recommissioning (if the building was commissioned previously) and retrocommissioning (if it's being commissioned for the first time) are beginning to be recognized as cost-effective ways to improve asset performance of existing buildings.

The next step after commissioning in an effective green-building project is post-occupancy evaluation (POE), which typically includes occupant satisfaction surveys and a review of energy use and is expanding into additional measures of acoustic and air quality, of safety and security, and of commuting impacts (Goins 2009). Aside from a handful of experts who advise on this process, POE is not yet consistently included in the scope of any one profession, so it remains an opportunity to be exploited.

Outside of the building, technical areas that are and increasingly will be in demand include rainwater management—especially using more ecologically sensitive approaches than the conventional gutters, pipes and detention basins—and the use of native plants and low-impact landscaping practices.

Other technologies that require both experience and coordination between design professions are vegetated surfaces (roofs and walls) and building-integrated solar collectors, both for photovoltaic and solar thermal.

Interpersonal skills:

The practice of integrative (or, as it more commonly called, integrated) design is still poorly valued, taught and understood, in part because it is so hard to teach outside of actual experience on real projects (E. McAteer, G. Shymko, M. Gentile, S. Pope interviews 2012). Coordinating and facilitating a large team process is tricky enough in person, but increasingly designers are being asked to do that work virtually, with a team that is rarely in the same place at the same time (K. Ritchie interview 2012).

To realize advanced and unconventional work, designers also need outstanding communication and sales skills: How do you sell a client on something adventurous (B. McCarry, S. Pope interviews 2012)?

And looking into the future, regenerative design skills, including integration of green features with social, economic and cultural ends, will increasingly be in demand (R. Cole interview 2012; Graham and Booth 2010).

4. Building Operators and Managers

Building operators and managers include the following:

- Facility managers
- Superintendents
- Custodians

Conventional interests and responsibilities:

Facility managers tend to be focused on avoiding surprises. Their first job is keeping occupants comfortable while spending as little money as possible. Much of their time is spent "putting out fires," especially if budget constraints or poor management have led to a lack of preventive maintenance and upkeep. That reactive mode too often turns into a vicious cycle in which time spent reacting to problems gets in the way of the proactive facility management that could prevent the problems from occurring.

As technologies evolve and get cheaper, sophisticated building management systems (BMSs) that were once affordable only for especially large and complicated buildings are becoming available to much smaller and simpler buildings. But the sophistication of these systems isn't always matched with a user-friendly interface or building operator training to use them effectively, so learning to set up and use these systems can be a challenge (J. Carney interview 2012). Due to the lack of technical training, in some cases the role of building manager has shifted to be more administrative and managerial, while technical tasks are subcontracted to outside vendors (D. Neate interview 2012).

Green building technical skills:

"Buildings work when the people running them get the signal that this matters," Jenny Carney summed up the situation in our interview (2012). This statement captures the gist of the challenge facing building managers and operators: they are asked to save energy and operate the building efficiently, but most owners don't back up those requests with resources for training, equipment and retrofits, or with job performance criteria that ensure these efforts are a personal priority. The least expensive of these is training, which, coupled with clear commitment from the owner, can make a big difference in building performance (J. Carney interview 2012).

The following key points also emerged from our interviews (2012):

- There is a lack of skills and understanding among operators that would enable meeting original design intent (T. Mueller).
- Building managers need training in green technologies, LEED, recommissioning (D. Neate).
- Increasingly, buildings are computer controlled but today's operators often come out of building trades where they may not have had much computer training (G. Trump, J. Carney).
- Operators need to be fluent in performance metrics and data trends, especially of energy use (J. Carney).
- Outside venders can be helpful for some services, but it's important not to underestimate the knowledge of operators who have been with a facility for a long time. Some energy audits by third parties produce recommendations that are not practicable, while operators with training and coaching may get more useful outcomes (J. Carney).

Interpersonal skills:

Managing a building inevitably also involves managing people, whether it's occupant behavior, investment decisions on the part of the owner, or dealing with colleagues, support staff and outside venders. Building operators and managers need more training in the soft skills that can help them engage with tenants and occupants as effective advocates for behavior change (D. Neate interview 2012).

5. Owners and Developers

- Owners
- Developers

Conventional interests and responsibilities:

Developers spend much of their time raising money for projects from investors and lenders, and marketing new developments. Green features are just beginning to be a factor in Canadian and US workspace leasing decisions by lessors with socially responsible reporting mandates—typically large, publicly traded corporations. Since these tend to be anchor tenants, they are having a significant impact on Class A+ office markets but have shown little effect as yet on less-prestigious market sectors.

Owners and managers of existing buildings are typically focused on maximizing net income from their assets; some are focused more on profits from asset resale. However, for most existing commercial buildings, utility operating costs are typically a small part of the financial picture, which is driven more by financing costs and by income losses due to unleased space. In at least one market (Toronto), development of new downtown LEED-Gold certified buildings has driven operators of existing buildings in the central business district to green operations and management.

Green building technical skills:

As procurement models change to fixed-fee, best value contracts, demand grows for integrated design-build-operate teams with good collaboration skills. These models also require sophisticated clients who know how to ask for what they want (K. Ritchie interview 2012).

Financial stakeholders' engagement in and contributions to sustainable development will increase in the coming years, not for altruistic reasons but in order to meet their own interests and goals (Cole 2011).

Interpersonal skills:

Owners are, in many ways, the most important target for paradigm-shifting, as they hold the purse-strings (B. Giles interview 2012). Therefore education and training for this audience should seek to draw them in based on the conventional values that drive their decision process (finances, managing risk), but lead into an exploration of personal and universal values as well.

6. Real Estate and Finance Sectors

This group includes those responsible for the evaluation, transactions, and financing of real estate:

- Investors
- Realtors
- Appraisers
- Lenders

Conventional interests and responsibilities:

The wide-ranging roles in this group are connected by their interest in the financing of the built environment. See the related CEC Trilateral Green Building Construction Task Force project Financing Models and Opportunities in the Green Building Construction Market in North America, for an in-depth analysis of the challenges and opportunities facing this sector.

Investors and lenders both provide capital and seek a return on their money, but their incentives are different: investors participate in the financial success of a project, so they may be willing to encourage some risk-taking in the hopes of increasing their return. Lenders, on the other hand, have a predetermined rate of return and therefore are interested primarily in minimizing risk (Malin 2007).

Appraisers play a crucial role in establishing the value of a property, based on recent transactions involving comparable properties and on other data. They rely on consistency in the market and struggle with establishing a value for innovative or unusual features. In areas where they are widely adopted, emerging building energy labeling and green building rating systems are beginning to affect valuations by some building appraisers, but lack of universal reporting requirements is likely to hinder this trend.

Realtors work to connect buyers with sellers and, like appraisers, tend to rely on established formulas to understand what buyers might be looking for, so they are also often challenged by unusual aspects of a

property. Realtors also eschew complexity because their incentive is to move properties as quickly as possible, and any wrinkles tend to slow the sales process (D. Little interview 2012). In the US and in at least one Canadian province (Ontario), realtors emerged as the principal opponents of regulations mandating disclosure of building energy consumption, concerned that this would add complexity to already-difficult transactions.

Green building technical skills:

Innovation in financing options is lagging behind the innovation that's happening in buildings, and fixing that will require policy changes and public-private partnerships, so policymakers need to understand both the financial side and the green building side much better than they do now (J. Westeinde interview 2012).

The lack of valuation of green and energy-efficient features is hindering the acceptance and development of these buildings (T. Mueller, J. Lobatón interviews 2012). Financing and valuation professionals have to become more creative to value and sell green properties effectively (J. Westeinde interview 2012). New research is emerging that green buildings can reduce financial risk, but this work is not yet widely known in the investment and finance sectors (World Green Building Council 2013).

Whereas real estate agents just need to understand how to value green assets conceptually, appraisers should be able to quantify them. It's relatively easy to quantify energy-related features, but much harder to put a dollar value on green features that don't translate directly into operating savings (J. Lobatón, D. Little interviews 2012).

Because they tend to be so risk-averse, lenders are the biggest obstacle in the effort to properly value innovative green properties. They sometimes reject more-sophisticated appraisals, and anything atypical is red-flagged in their assessment (D. Little interview 2012).

A bright spot in this sector is the handful of performance-based marketing programs, such as the energy bill and comfort guarantees offered by Ideal Homes in Norman, Oklahoma. The company can offer such guarantees to buyers of their homes because the homes have been designed and built with careful controls, to ensure success. A key element of these programs is training for all professionals and tradespeople, including those whose job it is to explain and sell the homes.

Interpersonal skills:

Unlike some other players in the building sector, realtors tend to be good at connecting with people and understanding their needs and interests—traits necessary for winning people's trust and closing deals. However, few realtors are yet aware of or consciously affected by demand for green, healthy homes and buildings, so there is currently little effort to communicate green real estate features in marketing efforts. At the same time, there is a tendency to use buzzwords like "green" without much justification. Boston Green Realty, an EcoBroker-certified firm, emphasizes its agents' ability to "identify, explain and

promote green and healthy features in homes" and warns of greenwashing, advertising the firm's services in "confirming if a property is truly green or not."

7. Manufacturers

Our focus within the building product manufacturing sector is on these two roles:

- Product development specialists
- Product reps

Conventional interests and responsibilities:

It takes a long time and significant investment to develop a new product and bring it to market. Before a company is willing to invest in the process it usually requires market studies to prove that there is interest, and after the product is developed it has to be tested and often certified for a wide range of physical and life-safety characteristics.

Product reps sell either directly to designers and contractors or indirectly to wholesalers and retailers, depending on the product and market sector. They seek to show how their product offers new solutions while minimizing the perception of risk from anything new or different.

Green building technical skills:

Manufacturers have to start creating and supporting more-complete solutions, rather than providing individual components and leaving it up to the subcontractors on the building site to get them installed and operating properly (V. Loftness interview 2012). This demand for integration applies to mechanical and electrical systems, which tend to be burdened by incompatible and difficult-to-use control systems. It also applies to building enclosure assemblies that have to be designed and built for thermal and moisture management, which requires a thorough understanding of all the layers and how they will interact. Corners, and intersections with doors, windows and other penetrations are especially trouble-prone in this regard (Yost and Melton 2012).

Manufacturers also face increasing pressure to understand and divulge specifics about the environmental footprint and any health hazards associated with the ingredients in their products. Over time, this demand is likely to expand to include health hazards from precursor substances and intermediaries as well (BuildingGreen staff 2012). The demand for transparency forces manufacturers to look carefully at the market advantages of being responsive to that call juxtaposed with concerns about giving up intellectual property and even potential legal risk if the information they divulge, which often comes from upstream suppliers, isn't accurate.

Interpersonal skills:

Leading product manufacturers are starting to create opportunities for themselves by collaborating with other manufacturers who make complementary products, to offer holistic, integrated packages to the industry for selected products and services. These collaborations require a different mindset on the part of the manufacturers, who have to learn to think of the opportunities and outcomes that are best for a whole project and to consider how production profits can be improved by reducing the life-cycle impacts of their products (Regenerative Ventures 2012).

Some manufacturers are also discovering that the new demand for transparency relating to product ingredients can become an opportunity to shift their entire relationship with design teams and owners from one of cagey compliance—responding as narrowly as possible to specific questions about whether a particular chemical of concern is in a product—to a relationship based on collaborative problem-solving. If manufacturers are willing to be transparent about product ingredients, they can engage the project team creatively in exploring why some potentially problematic substances are used and whether there might be better substitutes (James and Davis 2012). This kind of relationship leads to greater trust between suppliers and specifiers, which may translate into increased sales.

8. Municipal and other government officials

- Building code officials /inspectors
- Fire chiefs / public health officials
- Job safety inspectors
- Municipal planning and zoning staff

Conventional interests and responsibilities:

Building, health and fire safety officials traditionally see their role as one of ensuring occupant safety, and demand evidence that any innovative designs or technologies employed will not compromise that safety. At the planning and zoning level they seek to ensure compliance with local codes and regulations, and, more generally, public welfare. As a result, their perspective is historically focused on acute and direct effects, rather than diffuse environmental and resource impacts, and they are typically (and rightfully) conservative in assessing and approving innovations.

Green-building technical skills:

If government officials are to balance environmental performance and their current health and safety concerns, they will need to be equipped with a deeper understanding of health and safety benefits of green features, and how they should be implemented to avoid endangering these primary concerns.

Interpersonal skills:

These professionals need to be able to express concerns in a way that opens the door for creative solutions to address those concerns, rather than simply reject specific approaches. What are the concerns with those approaches and how can they be mitigated?

9. Specialty Consultants

There is a huge range of specialists who might be brought into a building project to lend their expertise. A few of the more common such specialists are listed here, but deep-green projects pursuing a fully integrated process (or "integrative," as some prefer to call it) are likely to also bring in experts with an ecological focus: biologists, wildlife ecologists, biomimicry professionals and the like.

- Building forensics specialists
- Building science advisors
- Commissioning agents
- Cost estimators
- Energy auditors/raters
- Energy consultants
- Enclosure consultants
- Lighting consultants

Conventional interests and responsibilities:

Specialty consultants have a specific area of expertise and are often challenged to learn enough about a project to provide reliable guidance within the limited time (and budget) available.

Green building technical skills:

Many of these consultants advise on aspects of the building that directly affect its green performance, so as the green-building movement evolves they have to stay abreast of—if not lead—efforts to optimize those aspects of the building's performance. As buildings change and new systems and functions are incorporated, they also have to understand how these changes affect the aspects of the building they're involved with. For example, enclosure consultants have to understand the implications of integrating photovoltaic panels or other energy-generating systems into the building façade, and acoustic consultants have to know about the noise that might come from new types of mechanical equipment.

The role of the cost estimator is especially critical in the integrated design process, which depends on real-time input on the cost implications of various options. But cost estimator training hardly exists in North America, with the exception of some programs in construction management schools. In the UK they are called quantity surveyors and there is specific training associated with that role. If we're going to succeed at finding integrated solutions and "tunnel through the cost barrier" (as described by Amory

Lovins of the Rocky Mountain Institute, 2012), then we need really smart and effective real-time costing (V. Loftness interview 2012).

One common problem with cost estimation in green projects is that estimators are seldom well-informed about systemic impacts of green features, so not all cost savings are assessed or presented in the decision-making process. For example, improved building enclosure thermal characteristics reduce heating and cooling loads and thereby reduce the size and cost of heating and cooling equipment. That cost savings is often captured in pricing out design alternatives, but the size and cost of distribution equipment (ducts and pipes) is seldom assessed by the mechanical engineer or communicated to the cost consultant, so significant potential savings are not considered. A well-educated cost estimator might know enough to inquire about the potential for such additional savings.

Interpersonal skills:

Like other members of a project team, specialty consultants need great collaborative working skills to contribute effectively in the emerging world of integrated practice.

10. Occupants

Buildings are created to house their occupants, or to otherwise shelter them for a time. They can only be called successful as green buildings if they perform that service and provide their inhabitants with a supportive habitat. Depending on the building's function, the occupants might be any of the following:

- Residents
- Students
- Employees
- Visitors
- Tenants

Conventional interests and responsibilities:

Depending on their role and contractual language, tenants and residents may be responsible for the cost of utilities. When they are, it can provide an incentive for them to engage in conservation behavior but reduces the owner's incentive to invest in energy efficiency measures. When they are not, there is little fiscal incentive to conserve costs they do not bear.

Green building technical skills:

Green projects generally have one or the other of these two philosophies regarding tenant engagement:

1. automate as much as possible because occupants can't be counted on to control thermostats, lights and shades efficiently; or
2. provide as much manual control as possible and train occupants on how to use them well.

This is true in both residential and commercial settings. In homes, automated systems have to be very simple to use and adjust, because professionals are not on hand to maintain them. For this reason, manually controlled systems are typically preferred, even though they may not be used optimally and can therefore lead to lower performance compared with properly functioning automated systems.

In commercial buildings, effective automation requires good commissioning and periodic recommissioning to run the building effectively. Advocates of these systems don't see it as their role to engage the occupants, except to respond to complaints, as needed, with adjustments to the controls.

Advocates of more-manual systems believe that giving occupants control over their environment contributes to making them more satisfied in that environment, and that teaching them to operate a building efficiently is one of the functions of a green project. They may also distrust automation because, if not programmed, commissioned and maintained properly, it will not perform as expected.

There is also a middle-ground approach, in which occupants are given limited control. For example, lights in classrooms can be programmed for "manual on, automatic off" operation, and thermostats can allow for manual adjustments within a narrowly defined band.

Depending on the direction in which green-building controls evolve, occupants will have to learn either to coexist with the automated environment around them or to actively control their environment. In either case, they need education on how strongly their choices can affect the performance of a building. For example, many tenants have antiquated requirements in their leasing agreements, for electrical capacity based on old office equipment (K. Ritchie interview 2012).

Interpersonal skills:

As the design and management of buildings evolve toward better energy and environmental performance, the occupants of buildings and communities will play a larger role in affecting the environmental impacts of the buildings they use and how the built environment evolves over time.

The building industry tends to see buildings as "done" when the occupants move in, but, as Stewart Brand points out in *How Buildings Learn* (Brand 1995), that is just the beginning of their life as entities that will either evolve or devolve over time, depending on how they are used and managed. The practice of regenerative design entails the creation not only of high-performance buildings, but also of an engaged community of occupants and others who will help the built environment continue to evolve toward better integration with natural systems (R. Cole interview; Mang and Reed 2011). From this perspective, the built environment can only transition to a (dynamic and evolutionary, not static) state of greater harmony with the natural environment if we as a society, and as inhabitants of that built environment, move toward that state as well.

At the moment, the general public has little awareness or understanding of the impact buildings have on global, regional and local environment quality, and even less understanding of the effects of occupant

behavior and use. This is a fundamental challenge; market demands drive the building development and real estate industries, and the education that underlies them. It is likely that there will continue to be only incremental progress until the urgency of environmental problems and the many ways buildings and people can address them are understood by the majority and become a higher societal priority for most.

Chapter 3: Canada and US: Education and Training Offerings, Gaps and Recommendations

Overview of Current Education and Training Offerings

Technical education on creating, operating and marketing buildings is already well established in Canada and the US. Many leading educational institutions are responding to market demands for education on green features and approaches. However, they are handicapped without a good understanding of the need for integration of design, construction and operational approaches, or of the market's capacity to absorb graduates with new green skills.

Our survey found a wide array of green building education and training programs for various workforce sectors. A sampling of these is listed in Appendix B and a few are profiled in more detail below. The settings for these programs range from multi-credit courses in degree-granting educational institutions to online videos and articles.

Some of these programs are designed to serve a range of workforce sectors with minimal customization. The LEED Training Workshops from the US and Canada Green Building Councils are an example of that model, a model which provides the valuable function of creating a common vocabulary and framework that help project teams communicate effectively across disciplines about green approaches. A drawback of this model is that the less tailored training may not resonate as effectively with people in some sectors as would a training program designed to address their specific needs and issues.

The counterparts to those broad-based programs are training programs developed for a specific trade or profession. In the design and engineering professions there are many such programs, including specific courses and even degree programs within institutions of higher learning. There are not as many such opportunities in the building trades. Some general training programs include green building features (for example, solar water heating or photovoltaic electricity) as part of their curriculum, but many do not.

Among the few dedicated green skills training programs for the building trades, we found strong endorsements of programs that are taught by people with first-hand experience on construction sites, that encourage peer-to-peer mentoring and that provide some context and rationale for the practices so trainees can understand the why of green building in addition to the what and how.

In parts of the US and Canada where green building practices are most advanced, training programs are relatively effective at meeting the needs. According to Globe Advisors: "Green building–related education and training institutions in British Columbia are doing a good job of preparing new entrants into the workforce for the current needs of industry" (Shorthouse 2012, 1). However, there are still many regions where green design and construction is not yet a major part of the market; these regions are handicapped in delivering high-quality education and skills transfer.

There are a few nascent programs that seek to address the holistic mindset issue directly. Pennsylvania State University's Energy Efficient Building Hub, for example, is developing an Integrative Design training program based on the principles of regenerative design. Pacific Gas & Electric in California is also in the process of developing such a program.

Profiles of Notable Education and Training Programs

A handful of successful programs are profiled here as examples. These are not intended to represent the most successful programs as we didn't attempt an evaluation that would allow us to rate them in that way. Instead we chose programs that exemplify the use of one or more specific strategies, which are called out specifically at the end of this section.

1,000 Green Supers	Sustainable Building Advisor Program	Accredited Green Plumbers Training	Pacific Gas & Electric Zero Net Energy Homes Training Series

1,000 Green Supers

- Workforce group: Building and property management
- Size/scale of program: Nearly 2,000 superintendents trained
- Region(s) served: New York City
- Gaps addressed: Gives building superintendents the tools to address energy efficiency and indoor environmental quality
- Exemplary features: Trainees go through in a cohort and have each other as resources; field experience is built into the course

New York City's 1,000 Green Supers program was established by SEIU Local 32BJ's Thomas Shortman Training Fund in 2009, with the goal of training 1,000 building superintendents in energy efficiency and indoor environmental quality. The program's successful first year garnered enough attention that in 2010 it received a $2.8 million grant from the US Department of Labor to expand the program. Property managers send their building superintendents to a 40-hour course that includes units on the building enclosure, lighting, HVAC and energy benchmarking; after passing written and field tests, the supers receive green building certification from the Building Performance Institute. The program also offers seminars and a "Green Coaching" workshop in which each super works one-on-one with a "coach" to develop a green plan for her or his building.

Sustainable Building Advisor Program

- Workforce group: Specialty consultants
- Size/scale of program: Nearly 2,000 students have completed the program

- Region(s) served: 28 locations in US and Canada
- Gaps addressed: Starting point for people, from a range of backgrounds, to become sustainable building consultants
- Exemplary features: Provides interdisciplinary connections among students from varied backgrounds

The Sustainable Building Advisor (SBA) program is certified nationally by the Sustainable Building Advisor Institute, and the annually updated curriculum is taught at a number of colleges and other locations around the US and Canada. Nearly 2,000 students have completed the program since 1999, and 1,250 of them have gone on to pass the Certified SBA exam. The course is intended for a range of backgrounds, including architects, realtors and planners. Program literature emphasizes the benefits of connecting with other students in the SBA courses, noting that a number of graduates have gone on to work together on projects.

Accredited Green Plumbers Training

- Workforce group: Plumbers
- Size/scale of program: More than 7,000 plumbers trained
- Region(s) served: US
- Gaps addressed: Education in water conservation and greenhouse gas emissions for those who install and repair plumbing systems
- Exemplary features: Engaging, convenient green education for a sector that doesn't necessarily seek it out

Accredited Green Plumbers, from the International Association of Plumbing and Mechanical Officials (IAPMO), has seen more than 7,000 plumbers complete its training program since it was launched in 2007. The 32-hour series of courses focusing on water conservation and reducing greenhouse gas emissions may be taken online or the organization may be hired to provide in-person training for a group of plumbers. Steve Lehtonen (interview, 2012), head of Accredited Green Plumbers Training, says that generating interest in green education can be difficult unless there is guaranteed demand from consumers. He says the online video format has proven popular for its convenience and engaging material, and that "if they get excited, then they'll learn. We had guys that were 50 or 60 say, 'I'm changed completely, I go to a ball game, walk around, and think they're wasting a lot of water.'"

Pacific Gas & Electric Zero Net Energy Homes Training Series

- Workforce group: Homebuilders, designers
- Size/scale of program: About 400 individuals trained
- Region(s) served: Northern California
- Gaps addressed: Transformational practices needed to go beyond energy efficiency to zero-energy performance
- Exemplary features: Holistic approach, engaging, knowledgeable instructors and comprehensive curriculum

This program, which includes both a New Homes curriculum and a Retrofits curriculum, has been extremely well received throughout California, in markets served by Southern California Edison, Sacramento Municipal Utility District, and San Diego Gas & Electric, as well as Pacific Gas & Electric. The New Homes series encompasses 48 instruction hours, and has been offered six times over the past few years. The Retrofit series spans 32 instruction hours and has been offered four times. This is one of the most popular of a wide range of education and training programs offered by Pacific Gas & Electric for both residential and commercial building markets.

Common elements of successful programs

There are many different successful programs, each with its own formula for success. No one program needs to incorporate all these elements, but every successful program includes at least one or more of them:

- Knowledgeable, charismatic trainers with experience in the field
- Peer-to-peer mentoring
- Online education that's accessible whenever the students can make time to use it
- Short-format instructional videos
- Focus on the "why" of green approaches in addition to the "what"

Gaps in the Current Offerings

Significant gaps in green education and training offerings fall into several categories:

1. Ecological Mindset and Awareness	2. Soft-skills Training and Mentoring	3. Financial Benefits and Evaluation	4. Training in Specific Technical Fields	5. Cross-disciplinary Education and Training

Each of these is discussed in more detail below.

1. Ecological mindset and awareness

An interconnected mindset as described in the practice of regenerative design is essential to a more fundamental solution of our ecological and social challenges. This type of awareness should ideally be infused throughout all training and education programs, but it remains the exception rather than the rule.

2. Soft-skills training and mentoring

Facilitation, collaboration and integrative design process management are essential for designers and builders. Even if they are not asked to lead these processes in their work, the training is useful to making them more effective participants. This training alone is not enough—the fundamental technical know-how and skills are still critical. But the addition of these soft skills can make those with technical know-how into key participants on any team.

3. Financial benefits and evaluation

The Globe Advisors report cites "the lack of workers and professionals with green building expertise" as one of five "important barriers" to growth of the green building and energy efficiency sector. However, workforce training and education are not among the report's top recommendations for accelerating growth of this sector. Instead it cites a different kind of education, "greater public and stakeholder education for the benefits, costs, and risks for building green," as well as measures addressed by other CEC Green Building Task Groups: "continuing public policy support through progressive, performance based building codes and regulations; a defragmentation of the construction process; and an evolution of green building incentive programs toward innovative and effective market-based financing models" (Shorthouse 2012, 1).

Appraisers need education about how to value green features of projects, especially in the face of a dearth of comparable properties with the same features. The Appraisal Institute offers some courses in this area, but only about 15% of appraisers are members of the Institute so it's not reaching a large segment of them. Also, their training is based on principles and abstract case studies, and is not as grounded as it could be in real-life situations (D. Little interview 2012).

4. Training in specific technical fields

Specific areas of expertise in which training programs are lacking, except in some of the most advanced regions in the US and Canada, are the following:

- Building envelope commissioning
- Energy modeling
- Building science for moisture management—designing and detailing to prevent air leakage and mold problems
- Solar systems design and installation
- Vegetated roof and wall systems design and installation

5. Cross-disciplinary education and training

The Globe Advisors report notes that "A greater emphasis on integrated building sciences, energy management, sustainability practices, and systems-based thinking in all real estate and construction industry programs would be beneficial" (Shorthouse 2012, 1).

Many of the specific technical fields listed above require cross-disciplinary collaboration. In every green building–related profession and trade, knowledge of how one's work intersects with and supports the work of others is essential to successful, cost-effective outcomes. This can be as demanding as passive cooling design—which requires multiple disciplines to balance desired comfort conditions, enclosure thermal and moisture characteristics, ventilation opening size, location, shading and control, internal thermal mass of structural elements, lighting and plug load equipment selection and acoustic control—or as basic as ensuring that plumbers and electricians understand the problems that inadvertent air and moisture barrier penetrations can cause.

Recommendations: New Programs, Enhancements and/or Expansion of Existing Programs

Based on our analysis of the needs, available programs, and opportunities, we have the following recommendations:

1. **Create a Peer Network for Trainers.** Convene a network of the most prolific and popular educators and trainers, and encourage them to teach each other about how to make their offerings broader in vision and scope and share those new capabilities with other teachers and trainers. This peer collaboration should work in both directions: enhancing soft skills and the principles of education for sustainability to technically minded trainers, and providing more technical skills to the process teachers. Top trainers will likely have to be paid for their time to participate in this network, at least initially.
2. **Support community colleges.** Identify and support best practices for technical training with a holistic global perspective at the community college level. With about 1,000 technical and community colleges in Canada, several dozen of which have signed onto the Pan-Canadian Protocol for Sustainability, there is a great network to engage. In the US there are over 1,600 community colleges, according to the US Department of Education. These local programs are uniquely positioned to offer the combination of science and math education and practical training the emerging workforce needs. These programs can be funded by both industry and government—industry, to quickly meet emerging needs for workers with new skills, and government, to train or retrain people to take those newfound jobs (Gordon et al. 2012). Such programs can be further supplemented with co-op job sessions, for more hands-on training. While these can support continuing education needs, they are especially well suited to teaching the incoming workforce.

3. **Match training with market demand.** Before supporting any technical skills program, ascertain that there is a demand for the skills provided, or develop a plan to build that demand so students don't learn unmarketable skills. Providing certificates or accreditation credentials can be helpful, but only if those credentials are supported by sufficient outreach to gain traction in the marketplace.
4. **Promote "Education for Sustainability" principles in various settings.** The practice and principles of Education for Sustainability as described by the Cloud Institute should be considered as a framework for imbuing new and evolving training programs with holistic, ecological consciousness. Similarly, a report on education policy for sustainable built environments suggests that we need "a participatory approach to eco-settlement education; one in which the teacher is also an experiential learner and the students/stakeholders also reflect on and share their experiences, thereby teaching each other. This is described in contemporary theory for education as a learner-centered approach" (Graham and Booth 2010).
5. **Don't expect a sustainability mindset to be a marketable skill.** Support programs that promote collaboration skills and education for sustainability mindsets, but consider these supplemental skills, not skills that are marketable in their own right.
6. **Transfer successful programs from advanced regions.** When specific capabilities are lacking in a given region, seek out education and training programs in other areas that are likely to be more advanced, and identify local organization institutions or organizations that can be supported with technical guidance and funding to expand or replicate those programs in the new region.
7. **Support a diversity of media and formats.** People all have different learning styles, lifestyles and ability to access learning opportunities. For that reason, it's important to offer training opportunities in a range of formats, from extended, in-person sessions to short online videos or articles. Experiential learning that combines theory with hands-on practice is particularly valuable with the emergent body of knowledge on creating, operating and maintaining green buildings.
8. **Teach financial literacy to designers.** Designers and other green building advocates have to learn how to talk about the benefits of green performance in terms that the financial community will relate to.
9. **Focus education on clients.** The best way to create demand for green projects is to show those who make decisions about buildings the value proposition. Reach these decision-makers, such as building owners and developers, through business media, events and social networks.

Chapter 4: Mexico: Education and Training Offerings, Gaps and Recommendations

While indigenous building methods that are still in use in parts of Mexico are very low-impact, Mexico's industrialized construction market is many years behind the US and Canada in overall acceptance of green building practices. From the perspective of balancing supply and demand, there is a need to focus mostly on the demand before investing too much in building the supply of green expertise to meet that demand. More simply: if government, real estate developers and constructors do not feel the need to develop greener buildings, teaching the workforce how to build them is useless.

Growing the demand for green buildings is also a training and education opportunity, however; but those needing the education are the owners, developers and commercial tenants who control the purse strings for construction projects. They may respond well to evidence that green buildings are more cost-effective to own and operate than non-green buildings. Another opportunity is to educate the policymakers who write building codes and develop incentive programs about the many societal benefits of greener buildings.

Overview of Current Education and Training Offerings

Green building education and training opportunities in Mexico are very limited. Many professionals and tradespeople in Mexico who are knowledgeable about green approaches gained that knowledge in other countries. One of the very few organizations offering green building training courses is the Mexico Green Building Council, and its offerings are quite limited and focused exclusively on understanding the LEED rating system.

The primary organization offering training in general to the construction industry is the Training Institute of the *Cámara Mexicana de la Industria de la Construcción*—the Mexican Chamber of the Construction Industry. While the Institute does not currently offer any green building programs, it is developing those courses now and plans to begin offering some in 2013 (P. Cristerna interview 2012).

Gaps in the Current Offerings

Given the limited availability of education and training related to buildings in general across all workforce sectors in Mexico, there are more gaps than can be listed here. The Recommendations, below, provide some suggested steps for improving the situation. In addition to a dearth of training opportunities, there is also a lack of building-related research and development facilities and capabilities (J. Westeinde interview 2012).

Even in those rare situations where the training is available, the challenge of motivating people to get trained in the absence of market demand (or with market demand, but without a clear accreditation program to confer status that the market recognizes) is especially significant in Mexico. In response, we

have to train the clients, to increase demand for green building generally and to improve the sophistication with which owners ask for and evaluate green performance (everywhere).

Recommendations: New Programs, Enhancements and/or Expansion of Existing Programs

1. **Education of government and private-sector leaders.** What we need in order to deliver green buildings and sustainable growth during the next ten years is to inform and teach the people who make the decisions at the top, mainly government officials but also private-sector leaders (F. Maiz interview 2012).
2. **Leverage academic knowledge to teach the industry.** The people who are very knowledgeable about all the needs pertaining to delivering green buildings are mainly professors at our universities. These people should also teach small and medium-sized contractors how to deliver green buildings (L. Canales interview 2012).
3. **Consistency can help collaboration.** A lesson from the US is that having a common language for green building helps professionals and tradespeople communicate effectively. All universities should align their academic and public programs to have coherence, as well address local environmental issues and requirements in order to enhance sustainable development (C.L. Garcia interview 2012).
4. **Make green part of all design and construction education.** Every professional who graduates from a Mexican university and who is somehow involved in the construction or design industry should learn to work sustainably. It shouldn't be an option (M. Elosua interview 2012). Restructure professional courses to address environmental issues and sustainable knowledge related to their field (C.L. Garcia interview 2012).
5. **Encourage programs to emerge organically.** Develop policies and incentives that summon the different sectors of the community (private sector and government) to take charge of their corresponding programs. The programs should be accessible (in schedule and budget) to each sector accordingly (C.L. Garcia interview 2012).
6. **Establish public-private partnerships for education.** Seek funding from different associations and government to establish programs and promote them to the different sectors (C.L. Garcia interview 2012).
7. **Use real-world, interdisciplinary examples in teaching.** During the program there should be real-case scenarios used, with the possibility of involvement of different sector participants (C.L. Garcia interview 2012).

Appendix 1: Workforce Sectors Characterized

Sector	Subgroups	Organizations that Provide Education and Training
Builders		Green Advantage, The Built Green Society of Canada, Natural Resources Canada, GreenStep, BuildingGreen, Inc., US Green Building Council, National Association of the Remodeling Industry, Urban Green Council, Yestermorrow Design/Build School, Brighter Green, Hanley Wood, Light House, Teska Capacitacion, Cemex Technology Center, Southface Learning Center, National Association of Home Builders, Pacific Gas & Electric, Energy and Environmental Building Alliance (EEBA)
	Construction managers	National Center for Construction Education and Research, Colorado State University, Everglades University, Canadian Construction Association, Urban Green Council, Milwaukee School of Engineering, British Columbia Institute of Technology, George Brown College, Ryerson University
	General contractors	Vancouver Regional Construction Association, Build It Green, Ontario Association of Architects, Hanley Wood, Canadian Construction Association
	Home builders	Southern Alberta Institute of Technology (SAIT), Organic Think, Inc., Efficiency First,
Building and property management		Ontario Association of Architects, BuildingGreen, Inc., US Green Building Council, BC Hydro and BC Institute of Technology, Seneca College, SEIU Local 32BJ, Canadian Institute for Energy Training
	Custodians	Saskatchewan Environmental Society, Natural Resources Canada, Urban Green Council
	Facilities managers	University of British Columbia, ASHRAE, Local Authority Services Ltd., Efficiency First, Saskatchewan Environmental Society, Centennial College, Natural Resources Canada, Association québécoise pour la maîtrise de l'énergie, Urban Green Council
	Insurance agents	
	Owners	
Building trades		YouthBuild, Yestermorrow Design/Build and UMass, National Center for Construction Education and Research, Efficiency First, BuildingGreen, Inc., National Association of the Remodeling Industry, Urban Green Council, British Columbia Institute of Technology, Algonquin College, Green Boots
	Carpenters	Carpenters International Training Fund
	Drywallers	
	Electricians	Urban Green Council
	HVAC contractors	Mechanical Service Contractors of America, CanSIA, National Center for Construction Education and Research, Urban Green Council
	Insulation and air sealing	Efficiency First
	Plumbers	International Association of Plumbing and Mechanical Officials, CanSIA, Urban Green Council
	PV installers	Kortright Centre for Conservation, UL, Interstate Renewable Energy Council (IREC), Ontario Solar Academy, National Center for

Sector	Subgroups	Organizations that Provide Education and Training
		Construction Education and Research, Ontario Association of Architects
	Roofers	
Design professions		Boston Architectural College, Catholic University of America School of Architecture and Planning, Philadelphia University, Harvard Graduate School of Design, Kansas State University, British Columbia Institute of Technology, BCIT Centre for Architectural Ecology, NJ Institute of Technology, University of Windsor, University of British Columbia School of Architecture, Cal-Poly Pomona College of Environmental Design, University of British Columbia, BuildingGreen, Inc., US Green Building Council, Urban Green Council, Yestermorrow Design/Build School, Brighter Green, Green Roofs for Healthy Cities, *Teska Capacitacion*, Greenhealth, U. Minn. School of Architecture, Southface Learning Center, George Brown College, Pacific Gas & Electric, Northeast Sustainable Energy Association
	Architects	Carnegie Mellon University, Cal-Poly College of Environmental Design, McGraw-Hill Construction, America Trade Solutions, University of Texas at Austin School of Architecture, Natural Resources Canada, GreenStep, Hanley Wood, Build It Green, Ontario Association of Architects, Energy and Environmental Building Alliance (EEBA), Southern Alberta Institute of Technology (SAIT), Rochester Institute of Technology, University of Oregon, University of Wisconsin–Milwaukee, Ball State University, Ryerson University
	Civil engineers	Milwaukee School of Engineering
	Electrical engineers	
	Interior designers	Hanley Wood, Rocky Mountain College of Art and Design, Algonquin College
	Landscape architects	Cal-Poly Pomona, University of Texas at Austin School of Architecture, Ball State University
	Mechanical engineers	University of British Columbia, ASHRAE, Ontario Association of Architects, Southern Alberta Institute of Technology (SAIT)
	Planners	US Green Building Council, University of Wisconsin–Milwaukee, Ball State University
	Specification writers	
	Structural engineers	Milwaukee School of Engineering
Manufacturers		US Green Building Council, America Trade Solutions, BuildingGreen, Inc.,
	Modular housing manufacturers	
	Product reps	
Municipal/ government		University of Texas at Austin School of Architecture, BuildingGreen, Inc., Cal-Poly Pomona College of Environmental Design, Local Authority Services, Ltd.
	Building code officials/inspectors	International Code Council, Southface Learning Center, George Brown College
	Fire chiefs	
	Job safety inspectors	

Sector	Subgroups	Organizations that Provide Education and Training
	Municipal planning and zoning	University of British Columbia School of Architecture, ITESM
Occupants		BuildingGreen, Inc.
Real estate and finance		Brighter Green, BuildingGreen, Inc.
	Appraisers	Appraisal Institute
	Bankers	
	Developers	
	Investors	
	Realtors	US Green Building Council, EcoBroker International
Specialty consultants		Sustainable Building Advisor Institute, Southface Learning Center, GreenStep, BuildingGreen, Inc., US Green Building Council, Cal-Poly Pomona College of Environmental Design, Ontario Association of Architects
	Building forensics	Ontario Association of Architects
	Building science advisors	Energy and Environmental Building Alliance (EEBA), Organic Think, Inc., Canadian Institute for Energy Training, University of British Columbia, Algonquin College, Ryerson University
	Commissioning agents	AABC Commissioning Group (ACG), Ontario Association of Architects, Canadian Institute for Energy Training
	Cost estimators	
	Energy auditors/raters	Centennial College, Organic Think, Inc., Efficiency First, Canadian Institute for Energy Training, Building Performance Institute
	Energy consultants	Natural Resources Canada, Clean Energy Institute of GPEKS, ASHRAE, Efficiency First, Canadian Institute for Energy Training, Building Performance Institute
	Enclosure consultants	Organic Think, Inc., Southface Learning Center
	Lighting consultants	Ontario Association of Architects

Appendix 2: Education and Training Programs Reviewed

Organization	Training program	Countries/regions
AABC Commissioning Group (ACG)	Certified Commissioning Agent / Certified Commissioning Technician	United States
Algonquin College	Centre for Construction Excellence	Canada
Appraisal Institute	Valuation of Sustainable Buildings Professional Development Program	United States
ASHRAE	ASHRAE Training Programs and Workshops	Mexico, United States & Canada
Association québécoise pour la maîtrise de l'énergie	*Centre de formation en maîtrise de l'énergie* (Centre for Training in Energy Management)	Canada: Quebec
Austin Energy	Green Boots	United States
Ball State University	College of Architecture and Planning	United States
BC Hydro, and BC Institute of Technology	Sustainable Energy Management Advanced Certificate	Canada: West coast
BCIT Centre for Architectural Ecology	Collaborations in Green Roofs and Living Walls	Canada: West coast
Boston Architectural College	The Sustainable Design Institute	United States and Canada
Brighter Green	National Sustainable Building Advisor Program	United States and Canada
British Columbia Institute of Technology	School of Construction and the Environment	Canada
Build It Green	Certified Green Building Professional	United States
Building Performance Institute	Home Energy Professional Pilot Program	United States
BuildingGreen, Inc.	BuildingGreen Continuing Education	United States
Built Green Society of Canada, The	EnerVision Builder Training	Canada: Prairie provinces
Cal-Poly College of Environmental Design	Concentration in Sustainable Architecture	United States

Organization	Training program	Countries/regions
Cal-Poly Pomona	Degrees in Landscape Architecture	United States
Cal-Poly Pomona College of Environmental Design	Master of Science in Regenerative Studies	United States
Canadian Construction Association	The Contractor's Toolbox for Projects Seeking LEED Certification	Canada
Canadian Institute for Energy Training	Canadian Institute for Energy Training	Canada
Canadian Institute for Energy Training	Multiple certifications and workshops	Canada
CanSIA	Solar Hot Water System Installer Certification	Canada
Carnegie Mellon University	Master of Science in Sustainable Design	United States
Carpenters International Training Fund	Green Construction: Certified Curriculum	United States
Catholic University of America School of Architecture and Planning	Master of Science in Sustainable Design	United States
Cemex Technology Center	Cemex Sustainable Development Courses	Mexico
Centennial College	Industrial and Building Energy eXpertise Training	Canada
Clean Energy Institute of GPEKS	Multiple course offerings	Mexico, United States and Canada
Colorado State University	Master's in Construction Management, Sustainable Building Emphasis	United States
EcoBroker International	EcoBroker Designation	Mexico, United States and Canada
Efficiency First	Efficiency First Webinars	United States
Energy and Environmental Building Alliance (EEBA)	EEBA Webinars on GreenExpo365	Mexico, United States and Canada
Everglades University	Bachelor of Science in Construction Management	United States
George Brown College	Centre for Construction and Engineering Technologies	Canada
Green Advantage	Green Advantage Environmental Certification	United States
Green Roofs for Healthy Cities	Green Roof Design 101-401	United States and Canada

Organization	Training program	Countries/regions
Greenhealth	Webinar: Sustainable Solutions for Stormwater Management at Healthcare Facilities	United States
GreenStep	LEED Training & Project Experience	United States
Hanley Wood	Hanley Wood University Continuing Education	United States
Harvard Graduate School of Design	Energy and Environments Concentration	United States
International Association of Plumbing and Mechanical Officials	Accredited Green Plumbers Training	United States
International Code Council	CalGreen Training	United States: California
International Code Council	IgCC Examiner & Inspector Certifications	Mexico, United States and Canada
Interstate Renewable Energy Council (IREC)	Interstate Renewable Energy Council (IREC) renewable energy and energy efficiency training	United States
***Tecnológico de Monterrey* (ITESM)**	School of Engineering in Sustainable Development	Mexico
Kansas State University	Ecological and Sustainable Design	United States
Kortright Centre for Conservation	Solar Professional Training Course / Solar for Building Professionals / Solar Hot Water Training Course	Canada: Ontario
Light House	Multiple course offerings	Canada: West coast
Local Authority Services, Ltd.	Energy Management Workshop	Canada: Ontario
McGraw-Hill Construction	Architectural Record Continuing Education	United States
Mechanical Service Contractors of America	GreenStar Designation	United States
Milwaukee School of Engineering	Building and Infrastructure Engineering programs	United States
National Association of the Remodeling Industry	Green Certified Professional (Remodeling)	United States
National Association of Home Builders	Master Certified Green Professional	United States
National Center for Construction Education and Research	Green Curriculum	United States

Organization	Training program	Countries/regions
National Center for Construction Education and Research	Sustainable Construction Supervisor	United States
Natural Resources Canada	Dollars to $ense Energy Management Workshops	Canada
Natural Resources Canada	R-2000 Builder Licensing	Canada
Natural Resources Canada	RETScreen Clean Energy Project Analysis Course	United States and Canada
NJ Institute of Technology	Certificate Program in Sustainable Design of Green Buildings	United States
Northeast Sustainable Energy Association	Zero Net Energy Homes Master Series Class	United States and Canada
Pacific Gas & Electric	PG&E Energy Education Classes	United States: California
Ontario Association of Architects	OAA+2030 Professional Series	Canada: Ontario
Ontario Solar Academy	Five Day Solar PV Design & Installation Course	United States and Canada
Organic Think, Inc.	My Green Curriculum	United States
Philadelphia University	Master of Science in Sustainable Design	United States
Rochester Institute of Technology	Master of Architecture program at Golisano Institute for Sustainability	United States
Rocky Mountain College of Art & Design	Interior Design: Green Design	United States
Ryerson University	Architectural Science programs	Canada
Saskatchewan Environmental Society	Building Operator Training	Canada: Prairie provinces
SEIU Local 32BJ	1,000 Green Supers	United States
Seneca College	Building Environmental Systems	Canada
Southern Alberta Institute of Technology (SAIT)	Southern Alberta Institute of Technology (SAIT) Green Buildings Technologies	Canada: Prairie provinces
Southface Learning Center	Alabama Energy Code Trainings	United States
Southface Learning Center	BPI Professional Training	United States
Sustainable Building Advisor Institute	Sustainable Building Advisor Program	United States and Canada
Teska Capacitacion	*Teska Capacitacion* LEED courses	Mexico
UL Knowledge Services	PV Installer Certification	United States

Organization	Training program	Countries/regions
University of British Columbia	Master of Engineering in Clean Energy	Canada
University of British Columbia	Sustainable Building Science Program	Canada
University of British Columbia School of Architecture	Bachelor of Environmental Design	Canada
University of Minnesota School of Architecture	Master of Science in Sustainable Design	United States
University of Oregon	Bachelor of Architecture and Master of Architecture programs	United States
University of Texas at Austin School of Architecture	Sustainable design programs	United States
University of Windsor	Advanced Professional Certificate in Energy Management	Canada: Ontario
University of Wisconsin–Milwaukee	School of Architecture & Urban Planning	United States
Urban Green Council	GPRO Fund+ Training	United States
Urban Green Council	GPRO Fundamentals of Building Green	United States
US Green Building Council	LEED Workshops—in person	United States and Canada
US Green Building Council	LEED Workshops—online	United States and Canada
Vancouver Regional Construction Association	Excellence in Sustainable Construction Certification Program	Canada: West coast
Yestermorrow Design/Build, and University of Massachusetts	Semester in Sustainable Design/Build	United States
Yestermorrow Design/Build School	Yestermorrow Certificate in Sustainable Building and Design	United States
YouthBuild	YouthBuild/Saint-Gobain Partnership	United States: Northeast, Midwest

Appendix 3: Interviewees

See the website of BuildingGreen's project, at <http://cec.fugue.com>, for highlights from each of the interviews.

Name	Affiliation	Workforce group
Canada – 14 Interviewees		
Dr. Ray Cole	Professor of Architecture, University of British Columbia	Architects Real estate and finance
Marsha Gentile	Construction Sustainability Specialist, Ledcor Group	General contractors
Eleanor McAteer	Project Director, Tower Renewal, City Manager's Office, City of Toronto	Municipal/government
Blair McCarry	Principal, Busby Perkins + Will	Architects Mechanical engineers
Ron Milich	Training Coordinator, International Association of Heat and Frost Insulators Local 101	Building trades
Thomas Mueller	President and CEO, Canada Green Building Council	All
Darryl Neate	Director of Sustainability, Oxford Properties Group	Building and property management
Stephen Pope	Sustainable Building Design Specialist, Natural Resources Canada / CanmetENERGY	Municipal/government
Derek Satnik	Managing partner, Mindscape Innovations	Building science advisors Energy consultants
Gordon Shymko	Principal, GF Shymko & Associates	Mechanical engineers Specialty consultants
Ian Theaker	Senior Sustainability Specialist, Pinchin Environmental Ltd.	Energy auditors/raters
Grant Trump	President and CEO, ECO Canada	Building trades Building and property management
Brad Watt	Education Coordinator, IBEW Local 353	Electricians
Jonathan Westeinde	Managing Partner, Windmill Development Group	Developers
Mexico—8 Interviewees		
Lorena Canales	Urban Development Manager, *Cámara Mexicana de la Industria de la Construcción* (CMIC)	Municipal/government
Perla Cristina Cristerna	Director, CMIC Capacitation Institute	Design professions

Name	Affiliation	Workforce group
		Building trades
Cindy Lira Garcia	Senior consultant, *Bioconstrucción y Energía Alternativa*	All
Victor Eduardo Pérez	Deputy Director of Social Sustainability, *Instituto del Fondo Nacional de la Vivienda para los Trabajadores* (Infonavit)	Bankers
Patricio Garza	Founder and CEO, One Development Group	Developers
José Lobatón	Founder and CEO, 9 *Proyectos*	Developers
Fernando Maiz	Founder and CEO, *Maiz Transforma, SA de CV*	Construction managers General contractors
César Ulises Treviño	Director, *Consejo Mexicano de Edificación Sustentable, AC* (Mexico Green Building Council)	Construction managers Structural engineers
United States—25 Interviewees		
John Abrams	CEO, South Mountain Company	Builders Architects
Gail Brager	Associate Director, UC–Berkeley Center for the Built Environment	Mechanical engineers Building science advisors Energy consultants
Jenny Carney	Principal, YR&G	Facilities managers Owners
Rick Chitwood	Founder, Chitwood Energy Management	HVAC contractors Energy auditors/raters
Jaimie Cloud	Founder and President, Cloud Institute for Sustainability Education	Occupants
David Dufresne	Education Director, International Code Council	Building code officials/inspector Municipal planning and zoning
Ann Edminster	Principal, Design AVEnues	All
Lance Fletcher	Director, Sustainable Design Institute at Boston Architectural College	Architects
Dakota Gale	Owner, Green Mortgage Northwest	Bankers
Barry Giles	Founder, BuildingWise	Facilities managers Owners
Scot Horst	Senior VP for LEED, US Green Building Council	All
Michael Ivanovich	Director of Strategic Energy Initiatives, Air Movement and Control Association	Energy consultants Mechanical engineers
Alison Kwok	Professor, University of Oregon Department of Architecture	Architects
Robert Lake	Chairman, Mechanical Service Contractors of America	HVAC contractors

Name	Affiliation	Workforce group
Steve Lehtonen	Senior Director of Environmental Education, International Association of Plumbing and Mechanical Officials	Plumbers
Debra Little	California Certified Appraiser	Appraisers Realtors
Joe Lstiburek	Principal, Building Science Corporation	Building science advisors
Vivian Loftness	Professor, Carnegie Mellon University School of Architecture	Manufacturers Design professions Building trades Building and property management
Robert Muldoon	Director, Green Building Initiative, Service Employees International Union Local 32BJ	Custodians Facilities managers
David Orr	Professor, Oberlin College	Design professions Occupants Real estate and finance
Peter Papesch	Chair of Sustainability Education Committee, Boston Society of Architects	Design professions
Kirsten Ritchie	Director of Sustainable Design, Gensler	Design professions
Annette Stelmack	Inspirit Interior Design	Interior Designers
Howard Styles	Training Director, International Union of Operating Engineers Local 94 NYC	Building and property management HVAC contractors
Jim Wasley	Architecture chair, University of WI-Milwaukee School of Architecture and Urban Planning	Design professions
Yancy Wright	Director, Sellen Sustainability	Building trades Builders

Appendix 4: Background documents

ASHRAE. 2010. *ASHRAE green guide*. Atlanta, GA: American Society of Heating, Refrigerating and Air-conditioning Engineers.

ASHRAE. 2012. *Instructions for participating in ASHRAE's high-performance building design professional (HBDP) certification program*. Atlanta, GA: American Society of Heating, Refrigeration, and Air-conditioning Engineers.

CMHC. 1999. *A project to promote implementation of the national building code and a standardized building permit in Prince Edward Island*. Prince Edward Island Home Builders' Association. Canada Mortgage and Housing Corporation.

Comisión Intersecretarial de Cambio Climático. 2009. *Programa especial de cambio climático 2009–2012*.

Conafor. 2008. *Tecnologias alternativas para el uso eficiente de recursos*. Comisión Nacional Forestal.

Construction Sector Council. 2011. *Green sustainable building in Canada: Implications for the commercial and residential construction workforce*. Ottawa: Construction Sector Council.

Earley, S.L. 2005. *Ecological design and building schools: Green guide to educational opportunities in the United States and Canada*. Oakland, CA: New Village Press.

ECO Canada Labour Market Research. 2011. *Building operators scoping study*. Calgary, AB: ECO Canada.

ECO Canada. 2012. *The green jobs map: Tracking employment through Canada's green economy*. Calgary, AB: ECO Canada.

European Center for the Development of Vocational Training. 2010. *Skills for green jobs: European synthesis report*. Luxembourg: Publications Office of the European Union.

Gould, K., and L. Hosey. 2006. *Ecological literacy in architecture education*. Washington, DC: American Institute of Architects.

Grueber, M., and T. Studt. 2010. 2011 Global R&D funding forecast. Rockaway, NJ: *R&D Magazine*. 15 December 2010.

Infrastructure Ontario. 2007. *Assessing value for money: A guide to Infrastructure Ontario's methodology*. Toronto, ON: Infrastructure Ontario.

International Code Council. 2012. *2012 IgCC code and commentary*. Washington, DC: International Code Council.

Kesik, T., and A. Miller. 2008. *Toronto green development standard cost-benefit study*. Toronto, ON: University of Toronto.

Loftness, V., et al. 2006. A progress report: Ecological literacy in architectural education. AIA Committee on the Environment. Slides.

Loftness, V., et al. 2009. Final report, ACSA topic groups for the accreditation review conference.

Moyes, R.E. 2001. *Opportunities for improving the inspections process*. Ottawa: Federation of Canadian Municipalities.

National Center for Construction Education and Research. File library. Available at <http://www.nccer.org/file-library.aspx?Category=3&search=spanish>. Accessed 20 November 2012.

Natural Resources Canada. CanmetENERGY website. Available at <http://canmetenergy.nrcan.gc.ca/>. Accessed 28 November 2012.

O'Leary, A., et al. 2012. *The competition that really matters: Comparing US, Chinese, and Indian investments in the next-generation workforce*. Washington, DC: Center for American Progress.

State of California Building Standards Commission. 2010. *2010 California green building standards code*. Sacramento: Building Standards Commission.

State of California Building Standards Commission. 2012. *Guide to the (non-residential) California green building standards code*. Sacramento, CA: California Department of Housing and Community Development.

State of California Division of Codes and Standards. 2012. *A guide to the California green building standards code Low Rise Residential*. Sacramento, CA: California Department of Housing and Community Development.

USGBC. LEED 201: Core concepts & strategies. US Green Building Council. Available at <https://new.usgbc.org/courses/leed-201-core-concepts-strategies?workshop_nid=1735356&return=/courses>. Accessed 21 November 2012.

Valdés, A.L. 2010. Casas en menos tiempo y bajo costo. CNNExpansión. Available at <http://www.cnnexpansion.com/obras/2010/11/16/prefabricada-vivienda-alpha-casaflex>. Accessed 27 November 2012.

Weismann, J. 2013. Shifting into a higher clean energy gear—New training safeguards aligned with jobs. Available at <http://www.renewableenergyworld.com/rea/blog/post/2013/02/shifting-into-a-higher-clean-energy-gear-new-training-safeguards-aligned-with-jobs>. Accessed 19 March 2013.

References

7group and B. Reed. 2009. *The integrative design guide to green building: Redefining the practice of sustainability*. Hoboken, NJ: Wiley & Sons.

Ander, G. 2012. Daylighting. *Whole building design guide*. <http://www.wbdg.org/resources/daylighting.php>. Accessed 23 April 2013.

Bapna, M. 2012. Rio+20: Seizing the opportunity for a sustainable future. WRI Insights. <http://insights.wri.org/news/2012/06/rio20-seizing-opportunity-sustainable-future>. Accessed 23 April 2013.

Brand, S. 1995. *How buildings learn: What happens after they're built*. New York, NY: Penguin Books.

BuildingGreen mission statement. Available at <http://www2.buildinggreen.com/about/bg>. Accessed 26 March 2013.

BuildingGreen Staff. 2012. *Avoiding toxic chemicals in commercial building projects*. Brattleboro, VT: BuildingGreen, Inc.

Cole, R.J. 2011. Motivating stakeholders to deliver environmental change. *Building Research & Information* 39(5): 431–435.

Gibson, B. 2009. The science in science fiction. *Talk of the Nation*. 30 November 2009. NPR. Timecode 11:55.

Goins, J. 2009. Occupant indoor environmental quality (IEQ) survey. Center for the Built Environment. <http://www.cbe.berkeley.edu/research/survey.htm>. Accessed 23 April 2013.

Gordon, K., L. Soares, and S. Steigleder. 2012. Preparing America's workforce for jobs in the green economy: A case for technical literacy. *Duke Forum for Law & Social Change* 4(1): 23–44.

Graham, P. and P. Booth. 2010. *Guidelines on education policy for sustainable built environments*. United Nations Environment Programme.

James, L., and M. Davis. 2012. What's in your product? Learning to love transparency. <http://www.greenbiz.com/blog/2012/06/30/what's-your-product-learning-love-transparency>. Accessed 29 March 2013.

Malin, N. 2007. Investing in the environment: The financial industry's approach to green building. *Environmental Building News* 16(11).

Mang, P., and B. Reed. 2011. Designing from place: A regenerative framework and methodology. *Building Research & Information* 40(1): 23–28.

McGraw-Hill Construction. 2012. *Construction industry workforce shortages: Role of certification, training and green jobs in filling the gaps*. Bedford, MA: McGraw-Hill Construction.

Melton, P. 2012. Verifying performance with building enclosure commissioning. *Environmental Building News* 21(12).

Regenerative Ventures. 2012. The network effect (RNx). Available at <http://regenerativeventures.com/rnx/>. Accessed 29 March 2013.

Shorthouse, P., et al. 2012. *British Columbia's green building & energy efficiency sector*. Vancouver, BC: Globe Advisors.

Turner, C., and M. Frankel. 2008. *Energy performance of LEED for New Construction buildings*. Washington, DC: USGBC.

Watson, Rob. 2011. *Green building market and impact report 2011*. Oakland, CA: GreenBiz.

World Green Building Council. 2013. *The business case for green building*. World Green Building Council.

Yost, P., and P. Melton. 2012. The hidden science of high-performance building assemblies. *Environmental Building News* 21(11).

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