

[www.cpwr.com](http://www.cpwr.com) • [www.elcosh.org](http://www.elcosh.org)



THE CENTER FOR CONSTRUCTION  
RESEARCH AND TRAINING

## Green and Healthy Jobs

Helen Chen, J.D., M.S.

Labor Occupational Health Program

University of California at Berkeley

June 2010

8484 Georgia Avenue  
Suite 1000  
Silver Spring, MD 20910

PHONE: 301.578.8500

FAX: 301.578.8572



© 2010, CPWR – The Center for Construction Research and Training

Research for this report was funded by CPWR – The Center for Construction Research and Training, using grant U54 OH008307 from the National Institute of Occupational Safety and Health (NIOSH).

The contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

CPWR is a 501(c)(3) nonprofit research and training institution created by the Building and Construction Trades Department, AFL-CIO, and serves as the research arm of the BCTD.

CPWR provides safety and health research and information for the construction trades and industry. For more information, visit [www.cpwr.com](http://www.cpwr.com).

## Table of Contents

Executive Summary.....	4
A. Introduction.....	8
B. Definition of a Green Job.....	10
1. Current definitions .....	10
2. Why is there a need to redefine green jobs? .....	12
3. A new definition of green jobs.....	15
4. Applying this definition to the construction industry .....	16
C. Green Jobs Sectors.....	20
D. Green Construction Job Growth .....	25
1. Current and projected employment.....	25
2. Drivers of green construction job growth .....	27
E. Hazards in Green Construction.....	30
F. Recommendations:.....	41
1. Incorporate worker health into the green jobs debate.....	41
2. Promote Prevention through Design.....	45
3. Incorporate worker health into green building certification programs .....	50
a. LEED .....	51
b. Other green building certification programs.....	533
c. A stand-alone worker health and safety rating system .....	55
d. Scorecard.....	57
4. Promote construction safety training.....	60
G. Conclusion .....	64
Appendix A: Case Studies.....	65
Appendix B: Resources.....	76
Bibliography .....	78

## Table of Figures

Figure 1: Green and decent jobs matrix .....	12
Figure 2: Green Jobs Sectors '.....	21
Figure 3: Green Construction Occupations.....	23
Figure 4: Summary of Occupational Hazards in Green Construction.....	31
Figure 5: Dealing with Uncertainty and Green Job Hazards .....	40
Figure 6: Types of Organizations Impacting Green Construction Jobs '.....	43
Figure 7: Construction Safety Scorecard .....	588

## Acknowledgments

Thank you to the following people who have provided guidance on this project: Robert Spear, Robin Baker, Dinorah Barton-Antonio, Diane Bush, Elaine El-Askari, Pam Tau Lee, Juliann Sum, and Valeria Velazquez. Thank you also to the many people that I interviewed for this project.

# Executive Summary

---

Green construction represents both our greatest opportunity in terms of mitigating climate change but also, because of the dangers inherent to high-hazard construction work, our greatest threat in terms of risk to workers. What we do at the nexus of green construction and occupational safety and health will set the standard for all green jobs.

This report collects the best available information to assess the coming tide of green construction jobs with the goal of looking for opportunities to elevate worker health and safety as a priority in the green building sector. This report examines the different and evolving definitions of green jobs, which are typically comprised of narrowly drawn environmental criteria and, sometimes, economic criteria promoting green jobs as “family-supporting” jobs.

A new definition of green jobs is proposed that includes broad environmental and economic criteria but also incorporates criteria to protect worker and community health. A “green job” should:

- contribute significantly to preserving or enhancing environmental quality;
- be economically sustainable (e.g., the job should pay a living wage, include benefits, and provide avenues for career advancement);
- promote the health and safety of workers; and
- never compromise the health and safety of surrounding communities.

Under this definition, some categories of construction jobs would not qualify as green. For example, because the primary purpose of highway construction is to enable driving, a major contributor to fossil fuel consumption, highway construction jobs would not qualify as green. Under this definition, a green building project might be comprised of both green jobs (such as solar panel installation) and non-green jobs (such as traditional concrete pouring), depending on the specific task at hand. This definition also forces us to explicitly balance any trade-offs that might occur between preserving environmental quality and protecting worker health.

This report presents one way to classify and categorize green jobs (including construction and non-construction jobs) (see Figure 2). It also offers an example of how occupations can be classified *within* the green construction sector (see Figure 3). Though data on green construction job growth is very limited, all studies agree that green building, particularly in the area of weatherization and retrofitting, will increase in coming years. Certain occupations -- including heating, air conditioning, and refrigeration mechanics and installers; insulation workers; helpers, carpenters; helpers, electricians; pipelayers, plumbers, pipefitters, and steamfitters -- will experience significant growth. A brief summary of the drivers of green construction growth is also given.

This report compiles a list of occupational hazards in the green construction industry and distinguishes between hazards that may increase in frequency (because of growth in green construction) and hazards that are associated with new technologies and products:

### **Summary of Occupational Hazards in Green Construction**

#### **Increased Risk of Existing Hazards**

Skylights: Falls  
Atriums: Falls  
Atriums: Ergonomics  
Recycling: Strains, Sprains, and Punctures  
Recycling: Slips and Falls  
Recycling: "Struck-by" Hazards  
Recycled Materials: Coal Ash in Concrete  
Weatherization: Lead and Asbestos Exposure  
Weatherization: Electrical  
Indoor Air Quality: Heat Stress

#### **Hazards Associated with New Technologies and Products**

Solar Power: Falls  
Solar Power: Electrical  
Solar Power: Exposure to Toxics  
Solar Power: Burns  
Solar Power: Ergonomics  
Wind Power: Falls  
Wind Power: Electrical  
Weatherization: Exposure to Isocyanate  
Weatherization: Exposure to Silica  
Building Materials: Exposure to Silica  
Building Materials: Exposure to Nanomaterials

The occupational hazards listed above are described more fully in Section E of this report and are supplemented by examples, workers' observations, and accompanying case studies (found in Appendix A). Together, these hazards point to a need for those in the occupational safety and health community to continue to push the green jobs movement to recognize and address worker hazards. The rapidly evolving nature of green building products and techniques requires us to be ever vigilant in detecting and addressing new hazards before they become persistent and quickly acting to eliminate existing hazards that we already know about and have the tools to address.

This report presents a range of recommendations for elevating construction safety as a priority in the context of green building. Changing the perception of what is green is the

first step that will help pave the way for many other strategies to protect worker health. We need to **incorporate worker health into the green jobs debate**. The ultimate goal is build public awareness so that when people think of green jobs, they are thinking not just of narrowly defined environmental issues but are asking what makes those jobs decent, safe, and just. To do this, some in the occupational health community will need to engage advocates, researchers, and policy analysts at an abstract level to broaden the still-evolving definition of green jobs to include worker health and other key components of sustainability. Others in the occupational health community will need to widely share the concrete, real stories about green construction workers who have become injured or even died on the job. We need to create in the public's mind an association between green jobs and worker health.

By doing so, we set the stage for making the structural changes that will institutionalize worker health protections as a part of the policies and practices related to green jobs. **Promoting Prevention through Design (PtD)** is one critical part of the solution -- by designing with construction safety in mind, some hazards can be greatly reduced or even eliminated altogether. There are many structural changes that need to be in place before PtD can be fully implemented, with costs, liability, and training being some of the major challenges. That being said, there is no other tool in our bag of tricks that can do more to eliminate hazards at their source than PtD.

Another recommendation is to **incorporate worker health into green building certification programs**. Green building certification programs like Leadership in Energy and Environmental Design (LEED) have not only succeeded in reducing the carbon footprint of specific buildings but have also helped raise public awareness about the need to address the energy use, water use, materials use, and indoor air quality of buildings. The challenge in the occupational health community is to find ways to elevate construction safety as a priority and encourage green building organizations to incorporate worker health criteria into existing rating systems. This report offers some possible adjustments to the LEED rating system to build in some degree of worker protection. It also suggests that we look to other local and regional green building programs that may be open to incorporating worker health, and use those programs to drive the market and push LEED and others to follow. This report also summarizes a stand-alone worker health and safety rating system, the Sustainable Construction Safety and Health Rating System designed by Sathyanarayanan Rajendran. Though such a rating system would take significant resources to implement, it represents the most comprehensive program for rating construction safety. Other recommendations include: pre-qualification systems that allow owners to select from a pool of contractors that have already been screened by a third party for safety; an easy-to-use scorecard that owners and developers could use to rate contractors on their own; and model contracts that include language to protect worker health and safety.

Finally, we need to **promote construction safety training**. This means evaluating current training programs for green construction workers and developing curriculum and modules that provide workers with practical skills, adequate health and safety training, and a framework for thinking critically about what building practices and materials are

truly green. This may entail reviewing the Occupational Safety and Health Administration's (OSHA) guidelines for teaching 10-hour and 30-hour construction trainings as well as pushing health and safety trainers in general to engage in more effective teaching methods. As an example of this, Appendix A is comprised of six case studies that have been used by the Labor Occupational Health Program at the University of California at Berkeley to teach green construction safety in a participatory way. Besides reaching construction workers, we also need to adequately train designers, owners, and contractors, and create cross-training opportunities to educate our allies and potential allies in the environmental and green building communities about green construction safety.

Adding the increased complexity of worker health to an already complex green jobs debate will be difficult, but this is the obligation we have to workers. Unless there is increased awareness among the public and among key decision-makers about the need to promote green construction safety, we will always be stymied in our efforts to implement the many changes needed in the construction industry. As the country slowly moves to embrace an environmental ethos, we have an opportunity to infuse that ethos with an accompanying respect and just treatment of the workers -- members of the current generation -- who are each doing their small part to protect the environment for future generations.

# A. Introduction

---

With each “revolution” in the economy, new jobs are created, but often come with tragic consequences. With the industrial revolution in the 19th century, we saw the rise of worker deaths from asbestosis, silicosis, brown lung disease, mine cave-ins, polluting factories, and more. Just as we began to get a handle on these traditional industries, our nation faced a computer revolution in the late 20th century that brought a startling rise in repetitive motion injuries for computer users. The new technology revolution also brought problems with toxic chemicals used in electronics manufacturing that have affected both high-tech workers and local communities.

In the 21st century, we look forward to a new revolution ushering in much-needed “green jobs.” With this change, we have an unprecedented opportunity to make sure, from the beginning, that these jobs are safe and healthy for both workers and communities. Nowhere is this more true than in the construction industry, where “green construction” is poised to become the new standard. While green jobs will reap environmental benefits, the impact on worker health could be severe in the construction industry, which employs 7% of the workforce yet accounts for almost a quarter of all work-related fatalities in the U.S., more than any other industry.<sup>1</sup>

Buildings represent the single largest potential in any sector of reducing greenhouse gas emissions.<sup>2</sup> In the U.S., buildings account for 39% of total energy use and 38% of the carbon dioxide emissions.<sup>3</sup> To reduce the environmental impact of buildings, building owners and designers are adopting green building practices that range from using old, time-worn techniques like improving the insulation in older homes to installing new technology like rooftop solar panels. Green building certification programs like Leadership in Energy and Environmental Design (LEED) have succeeded in reducing the carbon footprint of specific buildings but have also helped raise public awareness about the need to address the energy use, water use, materials use, and indoor air quality of buildings.

By all estimates, green construction will usurp more and more of the traditional construction market in years to come. For those in the occupational health community, this raises questions about the ability of this emerging sector to control occupational hazards such as rooftop falls during solar panel installation, electrical hazards associated with wind turbines, and exposure to toxic materials used in insulation products, recycled building materials, and solar panels.

---

<sup>1</sup> National Occupational Research Agenda (NORA) Construction Sector Council, *National Construction Agenda for Occupational Safety and Health Research and Practice in the U.S. Construction Sector* (National Institute of Occupational Safety and Health (NIOSH), 2008).

<sup>2</sup> United Nations Environment Programme, *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World* (2008).

<sup>3</sup> U.S. Environmental Protection Agency, *Why Build Green?* (accessed January 19 2010); available from <http://www.epa.gov/greenbuilding/pubs/whybuild.htm>.

At the project level, owners, designers, and contractors freely discuss green building design principles and practices, but construction safety rarely enters the equation. At the policy and institutional levels, construction safety is not seen as a component of green jobs. Accordingly, federal stimulus money to promote green jobs training does not stipulate training in occupational safety and health. Green building certification programs do not consider worker health in the calculation of whether a building is green. The mainstream public tours a green building and, while admiring the many creative green design features, does not stop to ask whether a building that does its part to protect the health of the environment also protects the health of workers. Until worker health is accepted as a component of green jobs, the safety of those who build the buildings we are so rightly proud of will always be an afterthought.

This report collects the best available information to assess the coming tide of green construction jobs with the goal of looking for opportunities to elevate worker health and safety as a priority in the green building sector. This report examines the different and evolving definitions of green jobs, which are typically comprised of narrowly drawn environmental criteria and, sometimes, economic criteria promoting green jobs as “family-supporting” jobs. An argument is made for redefining green jobs to include worker and community health components. A new definition is proposed and then applied to the construction sector.

This report presents one way to classify and categorize green jobs (including construction and non-construction jobs), and offers an example of how occupations can be classified *within* the green construction sector. Though data on green construction job growth is very limited, the best available estimates are given along with a summary of the drivers of green job growth.

The occupational hazards associated with green construction jobs are compiled and summarized here, along with examples, workers’ observations, and accompanying case studies (found in Appendix A). A set of recommendations follows. Some of these recommendations focus on providing and repackaging information through redefining green jobs, social messaging, and providing sufficient health and safety training for owners, designers, contractors, and workers. Other recommendations focus on promoting Prevention through Design efforts and incorporating worker health into green building certification programs.

Green construction represents both our greatest opportunity in terms of mitigating climate change but also, because of the dangers inherent to high-hazard construction work, our greatest threat in terms of the risk to workers. What we do at the nexus of green construction and occupational safety and health will set the standard for all green jobs.

## B. Definition of a Green Job

### 1. Current definitions

The definition of a green job is still in flux. Most definitions are limited to only environmental criteria, as opposed to economic or other criteria. The environmental criteria itself is under debate. In some definitions, green jobs only relate to climate change and/or energy use.<sup>4</sup> Other definitions are broad enough to encompass environmental issues such as water conservation and water quality, air quality, and wildlife protection, independent of climate change or energy use.<sup>5,6,7,8</sup>

A growing number of organizations, particularly unions and community organizing groups, are calling for the redefinition of green jobs to include not just environmental criteria but economic criteria. In this vision, a green job would not only protect the environment but would pay a living wage and provide benefits to workers. For example, Van Jones defines a green-collar job as “a family-supporting, career-track job that directly contributes to preserving or enhancing environmental quality.”<sup>9</sup> Changing the scope of the green jobs debate to include the economic sustainability component

#### *Working in **Green Jobs** and practicing **Green Chemistry** in the new **Green Economy***

Here is one way to think about the new “green” terminology:

Green jobs actively protect the environment. Green chemistry, by contrast, is a process of designing out environmental and human health hazards in the lifecycle of a product. The green economy is a broader term that encompasses both green jobs and green chemistry.

For example, the primary purpose of a solar panel installer is to install an alternative energy system that reduces the burning of fossil fuels. This is clearly a green job.

The primary purpose, however, of a nail salon worker is to beautify her client. By using a non-toxic nail polish, a product developed using green chemistry principles, she is a participant in the green economy but is not necessarily employed in a green job.

<sup>4</sup> Environmental Defense Fund, *Green Jobs Guidebook: Employment Opportunities in the New Clean Economy* (2008).

<sup>5</sup> Matt Gillen, Pietra Check, and Christine Branche, *Niosh Science Blog: Going Green: Safe and Healthy Jobs* (2010, accessed January 12 2010); available from [http://www.cdc.gov/niosh/blog/nsb010410\\_green.html](http://www.cdc.gov/niosh/blog/nsb010410_green.html).

<sup>6</sup> Andrea Buffa and others, *California's Global Warming Solutions Act of 2006: A Background Paper for Labor Unions* (University of California, Berkeley, Center for Labor Research and Education, 2008).

<sup>7</sup> Washington State Department of Ecology, *Washington's Green Economy: Clean Energy and Other Industries at a Glance* (2009, accessed December 15 2009); available from <http://www.ecy.wa.gov/climatechange/GreenEconomy.htm>.

<sup>8</sup> The Pew Charitable Trusts, *The Clean Energy Economy: Repowering Jobs, Businesses and Investments across America* (2009).

<sup>9</sup> Van Jones, *The Green Collar Economy: How One Solution Can Fix Our Two Biggest Problems* (New York: HarperCollins, 2008).

is starting to gain acceptance and, if successful, will be a major victory.

However, one component that is missing in even these broader definitions of green jobs is worker health. More recently, there has been some discussion that green jobs should also be safe for workers.<sup>10,11,12</sup> For example, the principles of the Green Justice Coalition state that: “Green jobs must be safe jobs, with decent pay and benefits that can support families.”<sup>13</sup> The Connecticut Council on Occupational Safety and Health calls for “4 G Jobs” that have four components: green collar (the product or service is environmentally green), green lungs (the workplace environment is green in terms of worker health and safety), green belt (the community environment is green), and green wallet (there is economic justice for the employees and community).<sup>14</sup> The 2010 Green Jobs, Good Jobs conference, sponsored by the BlueGreen Alliance Foundation, included several workshops that focused on occupational health.

Some organizations have offered formal definitions of green jobs that focus on environmental and economic criteria but also add on the need for “good” jobs. In *Greener Pathways*, the authors define green jobs as “family-supporting jobs that contribute significantly to preserving or enhancing environmental quality” and then go on to explain that a “green job is a good job” and good jobs pay more than a poverty wage, offer benefits (at least health care and ideally pensions), paid sick leave, *safe working conditions*, reasonable schedules, organizing rights, job security, and an accessible pathway to advancement.<sup>15</sup> The Middle Class Task Force, headed by Vice President Joe Biden, issued a staff report that includes “decent working conditions” as one of the components of the definition of a green job.<sup>16</sup> Similarly, the United Nations (UN) Environment Programme offers a more narrow definition of green jobs but then goes on to specify that green jobs should be decent and should include safe working conditions.<sup>17</sup>

---

<sup>10</sup> New York Committee for Occupational Safety and Health, "Are Green Jobs Safe Jobs?" (2008).

<sup>11</sup> Gillen, Check, and Branche, (accessed).

<sup>12</sup> Linda Delp and Elizabeth Stewart, *Green Buildings, Good Jobs, Safe Jobs: Social Justice Pathways to a Sustainable Los Angeles* (Los Angeles: UCLA Community Scholars Program, 2009).

<sup>13</sup> Mary Jo Connelly, *The Green Justice Solution: A Win-Win Plan to Prevent Climate Crisis and Jumpstart an Equitable and Sustainable Economic Recovery* (Green Justice Coalition and Community Labor United, 2008), 7.

<sup>14</sup> Connecticut Council on Occupational Safety and Health, "4 G Jobs."

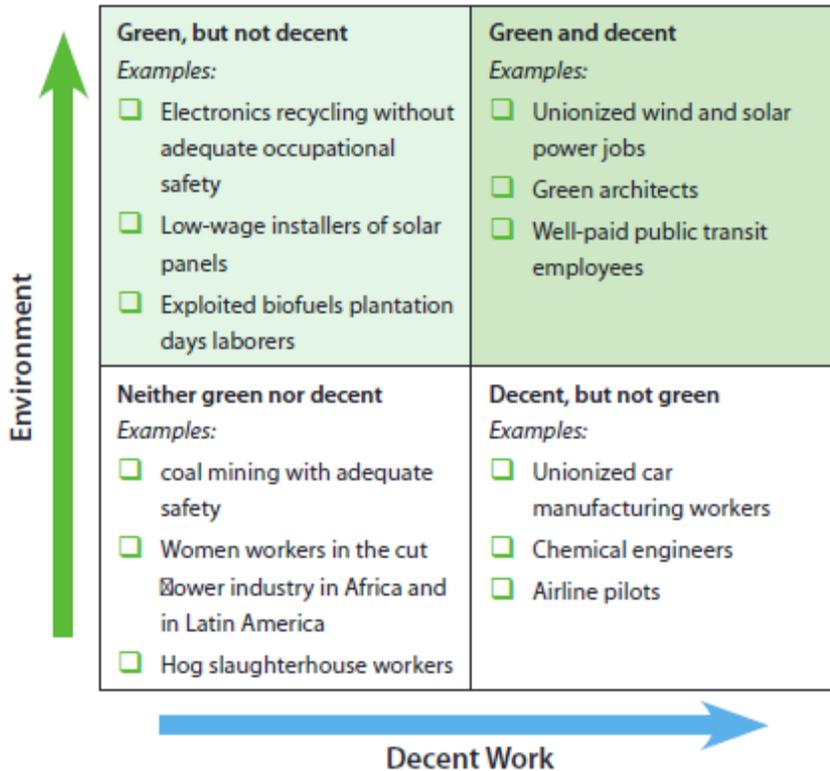
<sup>15</sup> Sarah White and Jason Walsh, *Greener Pathways: Jobs and Workforce Development in the Clean Energy Economy* (Center on Wisconsin Strategy, 2008). (emphasis added)

<sup>16</sup> The White House Task Force on the Middle Class -- Staff Report, *Green Jobs: A Pathway to a Strong Middle Class* (2009).

<sup>17</sup> "We define green jobs as work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high-efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution... Green jobs need to be decent work; i.e. good jobs which offer adequate wages, safe working conditions, job security, reasonable career prospects, and worker rights." United Nations Environment Programme, *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World*.

The UN also offers the following chart providing examples of jobs that are green and decent, green but not decent, decent but not green, and neither green nor decent:

**Figure 1: Green and decent jobs matrix** <sup>18</sup>



The hope is that, in the transition to a green economy, we can push jobs into the upper right corner, where jobs are green and decent. As David Michaels, the Assistant Secretary of Labor for Occupational Safety and Health, has stated: “It’s not a matter of choosing either a green future or safe jobs. It’s both. It’s all or nothing, and NIOSH (National Institute for Occupational Safety and Health), OSHA (Occupational Safety and Health Administration) and everyone else needs to play a role in building this sustainable economy - an economy that will provide sufficient jobs, green jobs, and jobs that are safe for all workers.”<sup>19</sup>

## 2. Why is there a need to redefine green jobs?

The call to include worker health in the green jobs dialogue is growing but is still a minority voice. Worker health needs to be institutionalized as a part of green jobs and

<sup>18</sup> Ibid.

<sup>19</sup> David Michaels, "Making Green Jobs Safe: Integrating Occupational Safety & Health into Green and Sustainability," in *NIOSH Going Green Workshop* (Washington, DC: 2009).

green building programs. For example, federal stimulus money promoting green jobs training does not specify worker health training. Green building certification programs do not consider worker health in the calculation of whether a building is green. Architects and engineers do not, as a routine matter, design with construction safety in mind.

How we name things and how we define them has meaning. One example of this lies with global climate change. John Holdren, Director of the Office of Science and Technology Policy in the Executive Office of the President of the United States, observes that the environmental community should never have allowed the term “global warming” to come into widespread use.<sup>20</sup> The term “global warming” implies gradual change (warming is less than heating) and implies that change is confined to rising temperature only (as opposed to weather patterns).<sup>21</sup> Holdren offers the term “global climate disruption”<sup>22</sup> as a more accurate term that, had we adopted it earlier, might have shaped the public debate more effectively and moved us away from the debating back and forth of localized temperatures that has so far stymied major environmental action. Turning back to green jobs, we have an opportunity here to shape the debate while it is still relatively early. Perhaps the catchy term “green jobs” has already stuck, but we can still change the scope of the debate and set the standards by which the success of the green jobs movement will be measured.

We need to think about the whole picture, and not just the narrowly defined physical environment. The environmental justice movement, which has often been at the forefront in protecting worker health, has long tried to redefine the environment to include not just flora, fauna, and soil/air/water quality but to redefine the environment, in the words of environmental justice activist Jeanne Gauna, as “where we live, work, and play.”<sup>23,24</sup> By drawing the scope of the environment more broadly, working conditions are an essential component of the environment and not one to be neglected or traded off in favor of narrow environmental goals. Admittedly, redefining the environment more broadly is difficult but it has helped served as a catalyst to mobilize communities living or working under hazardous conditions to take action and raise public awareness about the disproportionate risks borne by those communities.

Green jobs should not pose a threat to surrounding communities. For example, the manufacture of solar panels is considered a green job, but solar panel manufacturing creates a toxic by-product called silicon tetrachloride, which must be properly recycled or disposed of as a hazardous waste. In China, where solar panel manufacturing is a rapidly

---

<sup>20</sup> John P. Holdren. *Science and Technology for Sustainable Well-Being: Priorities and Policies in the Obama Administration*. Energy and Resources Group: 17th Annual Lecture on Energy and the Environment. University of California, Berkeley. April 22, 2010.

<sup>21</sup> *Ibid.*

<sup>22</sup> *Ibid.*

<sup>23</sup> SouthWest Organizing Project, *Environmental and Economic Justice*(accessed February 24 2010); available from <http://www.swop.net/environmental-justice>.

<sup>24</sup> Robert D. Bullard, "Anatomy of Environmental Racism and the Environmental Justice Movement," in *Confronting Environmental Racism: Voices from the Grassroots*, ed. Robert D. Bullard (Boston: South End Press, 1993).

growing industry, silicon tetrachloride is sometimes dumped just outside factories thus causing respiratory problems among villagers and killing crops.<sup>25</sup> We need to minimize the impact that green construction in this country has on other countries, particularly developing countries unable or unwilling to engage in responsible production. Closer to home, the construction dust created during remodeling or new construction can aggravate asthma and other respiratory problems among neighbors (See Section F.3.d of this report for model contract ideas to minimize construction dust). Whether the hazards take place overseas or at home, we need to apply the tools we have -- including green chemistry principles and life cycle analysis -- to all aspects of green building.

This push to think more wholistically about the environment is echoed by those who have called for jobs that are *sustainable* and not merely green.<sup>26</sup> The terms “green” and “sustainable” do not mean the same thing though they are often used interchangeably.<sup>27,28</sup> The term “green” typically has a narrower meaning and refers to the environmental impact of a building as measured by energy and materials use; water, soil, and air pollution; etc. The term “sustainability,” however, encapsulates the environmental, economic, resource, and social impacts of construction and demands that sustainability principles be applied throughout the life cycle of the building, from early planning and design to the building’s end of life.<sup>29,30</sup> The safety and health of construction workers would fall squarely under the social component of sustainability.<sup>31</sup> As framed by a working group of environmental justice organizations, “(s)ustainability is fundamentally a matter of equity and justice”<sup>32</sup> -- the fair and just treatment of workers is essential to a system that can sustain itself.

While it is still an uphill battle, there is already a movement to push for “decent” jobs, “good” jobs, and “quality” jobs that we can build on. In a report by Good Jobs First, the authors, including Apollo Alliance staff, state: “Given how much is at stake, the transition (to a green economy) must be approached with care. One of the greatest risks is that, in our haste to create a large *quantity* of new green jobs, we pay too little attention to their *quality*.”<sup>33</sup> Indeed, that is exactly the worry of the occupational health

---

<sup>25</sup> Ariana Eunjung Cha, "Solar Energy Firms Leave Waste Behind in China," *Washington Post*, March 9 2008.

<sup>26</sup> Anonymous, professor. Personal interview. March 8, 2010.

<sup>27</sup> John A. Gambatese, Sathyanarayanan Rajendran, and Michael G. Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health," *Professional Safety, Journal of the American Society of Safety Engineers (ASSE)* (2007).

<sup>28</sup> Michael Behm and others, "Prevention through Design and Green Buildings: A U.S. Perspective on Collaboration," in *CIB W099 Conference* (Melbourne, Australia: 2009).

<sup>29</sup> Gambatese, Rajendran, and Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health."

<sup>30</sup> Behm and others, "Prevention through Design and Green Buildings: A U.S. Perspective on Collaboration."

<sup>31</sup> Ibid.

<sup>32</sup> Alternatives for Community & Environment Inc., *Environmental Justice and the Green Economy* (2010).

<sup>33</sup> Philip Mattery and others, *High Road or Low Road? Job Quality in the New Green Economy* (Good Jobs First, 2009). (emphasis in original)

community, that worker health will be an afterthought, and that scores of workers in supposedly green jobs will be injured, become sick, or even die before we are able to put adequate protections in place.

### 3. A new definition of green jobs

With the environmental justice and sustainability framework as a backdrop, the following definition of a green job is proposed:

A “green job” should:

- **contribute significantly to preserving or enhancing environmental quality;**<sup>34</sup>
- **be economically sustainable (e.g., the job should pay a living wage, include benefits, and provide avenues for career advancement**<sup>35</sup>);
- **promote the health and safety of workers; and**
- **in no way compromise the health and safety of surrounding communities.**

This definition includes broad environmental and economic criteria, and incorporates criteria to protect both worker and community health. This definition, though it does not include every environmental justice principle and does not even go so far as to include a component that addresses racial justice, at least moves us one step closer to a vision of green jobs that is more sustainable. For the purposes of this paper, green construction jobs should strive to meet the definition for green jobs proposed above. The remainder of this report primarily focuses on the need to protect, and ways to protect, worker health.

---

<sup>34</sup> White and Walsh, *Greener Pathways: Jobs and Workforce Development in the Clean Energy Economy*,<sup>6</sup>

<sup>35</sup> Buffa and others, *California's Global Warming Solutions Act of 2006: A Background Paper for Labor Unions*.

## **4. Applying this definition to the construction industry**

Under the above definition of green jobs, some categories of construction jobs would not qualify as green jobs. Highway construction or maintenance would not qualify as a green job because building or maintaining highways does not contribute significantly to preserving or enhancing environmental quality. Even if green technologies or materials are used to make highway construction and/or repairs more environmentally friendly, these are jobs that, on the whole, enable our fossil fuel consumption by encouraging driving. Jobs related to new construction or renovation/retrofitting, whether commercial or residential, would need to be evaluated on a case-by-case basis.

### **Green buildings can be built with green and non-green jobs**

In determining whether a job is green, it is important to examine the specific job in question: a worker who is engaged in a green job must actually be performing tasks that contribute significantly to preserving or enhancing environmental quality. For example, a worker who is installing sustainable wood flooring in a building is engaged in a green job even if the rest of the construction project is not environmentally sound. However, a worker who is using conventional materials and methods to shingle a house or pouring concrete in a traditional way is not performing a green job, even if the overall construction project racks up enough credits to qualify as “green.” Just because a building as a whole is considered “green” does not mean that every single job on that project is also green by association. Allowing a roofer using traditional techniques to be deemed green merely by association would dilute the meaning of “green.” Being clear about the definition of green versus traditional jobs will help track our progress towards a green economy.

Under this interpretation of a green job, workers over the course of time may find themselves moving in and out of green jobs, depending on the specific task they are performing. A roofer may install a traditional roof one week and a green roof the next. From an employer’s perspective, a contractor constructing a green building may employ a variety of workers, some of whom are performing green jobs and some of whom are carrying out traditional tasks. Though the long-term goal may be to move every worker into exclusively green jobs and to have contractors build entirely green buildings, the slow transition to the green economy necessitates a mix of green and non-green tasks.

### **What is green will evolve**

Over time, our standards of what is considered green will change as technologies and methods evolve -- what is green today may not be green tomorrow. At the moment, bulky, heavy, stationary rooftop solar panels are the green standard. As the technology matures, it will almost certainly be the case that rooftop solar panels will one day be a considered a traditional product and a new product, as of yet undeveloped, will become the new green standard.

There is also the threshold question of *how* green something must be to be considered green. For example, if the traditional approach to landscaping is to use primarily exotic species, landscapers are surely engaged in green jobs if 99% of the plants they use are native species. But what if they are using only 50% native species? Or 10%? Can these “light green” jobs be considered green if only very small tweaks or fixes are made? In this case, the best approach is to reference existing standards and guidelines, such as LEED, American National Standards Institute (ANSI), and California’s new green building code (CalGreen) to ascertain industry standards, which are each of them evolving. Though there may be disagreement among these standards, there will at least be a range of acceptable targets.

Some have also raised the question of whether certain types of buildings could possibly be green just because it has certain green features. For example, could a sprawling mansion qualify as green just because solar panels are installed on the extensive roof? The amount of materials, fuel used to transport those materials, the pollution created through manufacturing those materials alone is likely to offset the energy savings from the solar panels. There are two issues here. First, the *building* itself may not be “green” and, certainly, by most green rating systems which require environmental features across many categories, would not qualify as such. As for the *jobs* associated with building the mansion, the job of putting up the walls might not be green, but the jobs associated with installing solar panels would be.

### **Dealing with trade-offs**

In determining whether a job preserves or enhances environmental quality, there will often be a trading off of environmental benefits and harms. For example, sustainable wood flooring certified by the Forest Stewardship Council (FSC) comes from responsibly managed forests in which the environmental impact of logging activities is reduced and indigenous peoples' rights are respected.<sup>36</sup> However, if FSC-certified wood is shipped thousands of miles from Brazil to the United States, the amount of energy and inputs required to transport the material may overwhelm the environmental benefit. This kind of balancing of different environmental factors is addressed in some rating systems<sup>37</sup> and could also be tackled using life-cycle analysis.<sup>38</sup>

---

<sup>36</sup> Forest Stewardship Council, *The Fsc Principles and Criteria for Responsible Forest Management* (accessed November 16 2009); available from <http://www.fsc.org/pc.html>.

<sup>37</sup> In LEED 2009 For New Construction and Major Renovations, LEED awards one point if 10% of building materials and products are extracted, harvested or recovered, and manufactured from within 500 miles of the project site and two points if 20% of materials are sourced from within 500 miles. LEED also awards one point for using at least 50% of wood-based materials certified by FSC. U.S. Green Building Council, *Leed 2009 for New Construction and Major Renovations* (Washington, D.C., 2009). A project team hoping to maximize LEED credits might source *local* FSC-certified products or, if that is not possible, source a portion of the building materials locally and a portion from forests elsewhere that are FSC-certified.

<sup>38</sup> The concept behind life-cycle analysis is a way of evaluating the environmental impact of a product from “cradle to grave.” While there are various tools for assessing the life-cycle of a product, none address worker health and safety.

In a similar vein, environmental benefits/harms may trade off with worker health benefits/harms. In an example from the auto repair industry, when the use of chlorinated solvents as degreasers were phased out in California to reduce dioxin pollution, a new substitute, hexane, was introduced.<sup>39,40</sup> Hexane, a neurotoxin, was used in high volumes and with few restrictions, and soon after, many workers began experiencing numbness of their hands and feet and some even become wheelchair-bound.<sup>41,42</sup> This example illustrates the challenges associated with chemical and product substitution; sometimes, a product that is beneficial to the environment may negatively impact human health.

The above example underscores the importance of considering worker health criteria for what constitutes a green job. If worker health is not explicitly considered a component of green jobs, it is much easier to overlook the worker health impact and trade it off in favor of narrowly defined environmental gains.

As the definition of green jobs is not yet fixed, there is still an opportunity to shape it. One union-based advocate has asked, "Why not shape [the definition of green jobs] so that health and safety is there from the get-go? ... The green economy hasn't hit yet. There's still time."<sup>43</sup> Pushing a new definition of green jobs will be challenging because it requires that we push an issue – worker health – that may not be familiar to many in the environmental community. However, it is exactly this lack of knowledge about worker health that makes it easy to trade off worker health in favor of environmental benefits, as described above.

Redefining green jobs will also be met with disapproval from those who feel that advocating for green jobs is difficult enough without adding worker health as extra baggage. As one labor advocate in the occupational health and safety community has said, "Let the greens have their day; we'll have ours."<sup>44</sup> It is true that it is often easier to win incremental change but we have a unique opportunity here to merge the environmental and worker rights movements in a powerful way. The emergence of the Blue-Green Alliance, which unites environmental organizations and labor unions, is an example of a partnership that has the potential to build understanding across two communities that, historically, have faced off in the perceived "jobs versus environment" conflict. Alliances like these have an important role to play in shaping public messages in a way that can further both environmental and labor goals.

This is an opportunity to promote worker health beyond the confines of the Federal Occupational Safety and Health (OSH) Act and state plans. As we know, OSHA enforcement is chronically underfunded and occupational safety and health violations

---

<sup>39</sup> Michael P. Wilson and others, *Green Chemistry: Cornerstone to a Sustainable California* (The Centers for Occupational and Environmental Health, University of California, 2008).

<sup>40</sup> Lee Bishop and Mitch Anstey, "Green Chemistry: Chemists Clean up Their Act," *Berkeley Science Review*, no. 16 (2009).

<sup>41</sup> Wilson and others, *Green Chemistry: Cornerstone to a Sustainable California*.

<sup>42</sup> Bishop and Anstey, "Green Chemistry: Chemists Clean up Their Act."

<sup>43</sup> Anonymous, union. Personal interview. March 22, 2010.

<sup>44</sup> Anonymous, union. Personal interview. February 16, 2010.

occur all the time without proper enforcement measures. Redefining green jobs to include worker health would add another layer of protection for workers by engaging owners, contractors, and designers in a concerted effort to prevent injuries and illnesses. Giving owners, contractors, and designers additional incentives and tools to protect workers is helpful in a system where the enforcement agency does not have the resources to show up at the great majority of worksites.<sup>45</sup>

Furthermore, the appeal of voluntary green certification and green building programs is that they declare an environmental consciousness that goes beyond what is required by law. If green certification and rating systems were to incorporate worker health and safety criteria, these criteria would push construction safety beyond the minimum legal requirements, which could potentially mean much lower injury and illness rates and would project a powerful image of social consciousness.

Finally, even if there is not a mainstream adoption of a new, more wholistic definition of green jobs, we have an obligation to raise awareness about worker health issues and add needed complexity to a debate that tends to discount worker health. It would be unjust if workers had to settle for being “grateful” for the existence of any job at all if those jobs ended up creating disproportionate health and safety risks to workers.

---

<sup>45</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

## C. Green Jobs Sectors

---

Green jobs have been categorized and classified in many different ways. Some classification systems group green jobs in to very broad categories.<sup>46,47</sup> For example, the United Nations Environment Programme puts jobs into five categories: agriculture, manufacturing, research and development, administrative activities, and service.<sup>48</sup> Other systems break down green jobs into more specific categories.<sup>49</sup> One such system was developed by The National Center for O\*NET Development, which is under the direction of the U.S. Department of Labor. It is presented below with some modifications per Raquel Pinderhughes' study, *Green Collar Jobs*:

---

<sup>46</sup> The Pew Charitable Trusts, *The Clean Energy Economy: Repowering Jobs, Businesses and Investments across America*. (classifying jobs as Clean Energy, Energy Efficiency; Environmentally Friendly Production; Conservation and Pollution Management; and Training and Support)

<sup>47</sup> Robert Pollin and others, *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy* (Political Economy Research Institute (PERI) at University of Massachusetts-Amherst and Center for American Progress, 2008). (classifying jobs as Building Retrofitting; Mass Transit/Freight Rail; Smart Grid; Wind Power; Solar Power; and Advanced Biofuels)

<sup>48</sup> United Nations Environment Programme, *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World*.

<sup>49</sup> Environmental Defense Fund. (classifying jobs as Low Carbon Power & Renewable Power; Carbon Capture & Storage; Energy Storage: Equipment & Systems; Energy Efficiency and Demand Response; Green Buildings; Transportation; Carbon Markets: Trading & Projects; Climate Change Adaptation; Public-sector/Government; Consulting & Research; Waste Reduction & Management; and Non-Profit Sector).

**Figure 2: Green Jobs Sectors** <sup>50,51</sup>

<p><b>Renewable Energy Generation</b> Includes solar, wind, geothermal, and biomass, as well as non-renewable sources of energy undergoing significant green technological changes.</p> <p>▶ Examples of Green Construction Occupations: Geo-thermal Sheet Metal Workers, Solar Photovoltaic Installers</p>
<p><b>Transportation</b> Covers activities related to reducing environmental impact of transportation.</p>
<p><b>Energy Efficiency</b> Includes increasing energy efficiency and making energy demand response more effective (e.g., “smart grids”).</p> <p>▶ Examples of Green Construction Occupations: Boilermakers, Insulation Installers</p>
<p><b>Water Conservation</b> Includes water conservation and adaptive grey water reuse</p>
<p><b>Green Construction</b> Covers activities related to constructing new green buildings, retrofitting residential and commercial buildings (weatherization), installing other green construction technology, and use of less toxic materials in construction.</p> <p>▶ Examples of Green Construction Occupations: Carpenters, Hazardous Materials Handlers, Iron and Steel Workers, Laborers, Roofers, Welders</p>
<p><b>Energy Trading</b> Covers financial services related to buying and selling energy.</p>
<p><b>Energy and Carbon Capture and Storage</b> Covers activities related to capturing and storing energy and/or carbon emissions.</p>
<p><b>Research, Design, Consulting, and Educational Services</b> Encompasses “indirect jobs” to the green economy which includes activities such as energy audits, consulting, research, and education.</p>
<p><b>Environmental Protection</b> Covers activities related to environmental remediation, climate change adaptation, and ensuring or enhancing air quality.</p>
<p><b>Agriculture and Forestry</b> Covers activities related to using natural pesticides, efficient land management or farming, and aquaculture.</p>
<p><b>Manufacturing</b> Includes green chemistry and activities related to industrial manufacturing of green technology including green building products.</p>
<p><b>Recycling and Waste Reduction</b> Covers activities related to solid and hazardous waste and wastewater management including construction and demolition waste.</p>
<p><b>Governmental and Regulatory Administration</b> Covers activities associated with conservation and pollution prevention, regulation, enforcement, and policy work.</p>

<sup>50</sup> Erich C. Dierdorff and others, *Greening of the World of Work: Implications for O\*Net-Soc and New and Emerging Occupations* (National Center for O\*NET Development, 2009).

<sup>51</sup> Raquel Pinderhughes, *Green Collar Jobs* (The City of Berkeley Office of Energy and Sustainable Development, 2007).

As can be seen from the chart above, green construction jobs can be found in the Green Construction, Renewable Energy Generation, and Energy Efficiency sectors.

Further detail on these green construction jobs can be found in the next chart. The National Center for O\*NET Development, divides green jobs into three categories:

- Green Increased Demand Occupations: These are traditional jobs for which no significant changes in work or worker requirements are needed to fit into the new context of the green economy.
- Green Enhanced Skills Occupations: In these jobs, the purpose of the occupation remains the same, but tasks, skills, knowledge, and external elements, such as credentials, have been changed.
- Green New and Emerging (N&E) Occupations: These are new jobs born out of the need for unique work and worker requirements.<sup>52</sup>

The following chart is a selection of green jobs as they related to *construction*. Again, these green construction jobs can be found in the renewable energy, energy efficiency, and green construction sectors. Note that some jobs have a classification code but that new and emerging jobs do not.<sup>53,54</sup>

---

<sup>52</sup> Dierdorff and others, *Greening of the World of Work: Implications for O\*Net-Soc and New and Emerging Occupations*.

<sup>53</sup> The National Center for O\*NET Development matched Green Increased Demand Occupations and Green Enhanced Skills Occupations with their appropriate O\*NET Standard Occupational Classification (O\*NET-SOC) Code, which is a system for classifying occupations. The O\*NET-SOC taxonomy allows the Bureau of Labor Statistics and other agencies to track employment and other data for specific occupations.

<sup>54</sup> Note that the terms “occupation” and “job” are used interchangeably here. However, technically, there is a difference between “jobs” and “occupations.” Job titles refer to specific work activities. Occupations are broad, well established groupings of workers defined by the Standard Occupation Classification (SOC) system. Employment, wage, and competency data are collected for occupations but not for job titles. One occupation can be comprised of multiple job titles. For example, in the occupation category, Electrical Engineers (SOC 16-2071), two corresponding job titles include: Wind turbine electrical engineer and Wind farm electrical systems designer. See Robert Sentz, *Green Pathways: A Data-Driven Approach to Defining, Quantifying, and Harnessing the Green Economy (Green Jobs, Part 3)* (Economic Modeling Specialists Inc., 2009).

**Figure 3: Green Construction Occupations**

Sector	Category	Reported Occupation	O*NET-SOC Code	O*NET-SOC Title
<b>Renewable Energy Generation</b>	<i>Green Enhanced Skills</i>	Geo-thermal Sheet Metal Workers	47-2211.00	Sheet Metal Workers
	<i>New and Emerging</i>	Solar Energy Installation Managers		
		Solar Photovoltaic Installers		
		Solar Thermal Installers and Technicians		
		Wind Turbine Service Technicians		
<b>Energy Efficiency</b>	<i>Green Increased Demand</i>	Boiler Technicians	51-8021.00	Stationary Engineers and Boiler Operators
		Boilermakers*	47-2011.00	Boilermakers
		Insulation Installers*	47-2131.00	Insulation Workers, Floor, Ceiling, and Wall
		Insulation Workers*	47-2131.00	Insulation Workers, Floor, Ceiling, and Wall
	<i>Green Enhanced Skills</i>	Ground Water/Heat Pump Contractors or Installers*	49-9021.01	Heating and Air Conditioning Mechanics and Installers
		Heating/Air Conditioning Installers*	49-9021.01	Heating and Air Conditioning Mechanics and Installers
		HVAC Operations and Maintenance Technicians	49-9021.01	Heating and Air Conditioning Mechanics and Installers
<i>New and Emerging</i>	Weatherization Installers and Technicians			
<b>Green Construction</b>	<i>Green Increased Demand</i>	Boilermakers*	47-2011.00	Boilermakers
		Carpenter Helpers	47-3012.00	Helpers--Carpenters
		Carpenters	47-2031.01	Construction Carpenters
		Carpenters	47-2031.02	Rough Carpenters
		Cement Masons	47-2051.00	Cement Masons and Concrete Finishers
		Construction Equipment Operators	47-2073.00	Operating Engineers, Other Const. Equipment Operators
		Electricians	47-2111.00	Electricians
		Industrial Truck Drivers	53-7051.00	Industrial Truck and Tractor Operators
		Installation Helpers	49-9098.00	Helpers--Installation, Maintenance, and Repair Workers
		Insulation Installers*	47-2131.00	Insulation Workers, Floor, Ceiling, and Wall
		Insulation Workers*	47-2131.00	Insulation Workers, Floor, Ceiling, and Wall
		Iron and Steel Workers*	47-2221.00	Structural Iron and Steel Workers
		Laborers*	53-7062.00	Laborers and Freight, Stock, and Material Movers, Hand
		Metal Fabricators*	51-2041.00	Structural Metal Fabricators and Fitters
		Operating Engineers	47-2073.00	Operating Engineers, Other Const. Equipment Operators
		Refrigeration Engineers*	49-9021.02	Refrigeration Mechanics and Installers
		Welders*	51-4121.06	Welders, Cutters, and Welder Fitters
	Welders, Cutters, Solderers & Brazers*	51-4121.06	Welders, Cutters, and Welder Fitters	
	Welders, Cutters, Solderers & Brazers*	51-4121.07	Solderers and Brazers	
	<i>Green Enhanced Skills</i>	Biofuels Plant Construction Workers	47-2061.00	Construction Laborers
		Construction Laborer	47-2061.00	Construction Laborers
		Construction Laborers	47-2061.00	Construction Laborers
		Construction Managers	11-9021.00	Construction Managers
		Cool Roofing Installers	47-2181.00	Roofers
		Energy Efficient Site Foremen	11-9021.00	Construction Managers
		Green Plumbers and Pipefitters	47-2152.01	Pipe Fitters and Steamfitters
		Green Plumbers and Pipefitters	47-2152.02	Plumbers
		Ground Water/Heat Pump Contractor/Installers	49-9021.01	Heating and Air Conditioning Mechanics and Installers
		Hazardous Materials Handlers*	47-4041.00	Hazardous Materials Removal Workers
		Heating/Air Conditioning Installers*	49-9021.01	Heating and Air Conditioning Mechanics and Installers
		Plumbers, Pipefitters and Steamfitters	47-2152.01	Pipe Fitters and Steamfitters
		Plumbers, Pipefitters and Steamfitters	47-2152.02	Plumbers
		Roofers	47-2181.00	Roofers
		Sheet Metal Workers*	47-2211.00	Sheet Metal Workers
Site Supervising Technical Operators		11-9021.00	Construction Managers	
Solar Commercial Installation Electrician Foremen		11-9021.00	Construction Managers	
Solar Installation Manager/Project Foremen	11-9021.00	Construction Managers		

Though the U.S. government currently does not have the capacity to fill in meaningful employment figures for the occupations above,<sup>55</sup> the U.S. Bureau of Labor Services, as described below, is preparing to collect and compile this data.

Figure 3 is a useful tool for identifying the occupations that may encounter job growth in coming decades as the green economy expands and for identifying areas in which the construction workforce may need re-tooling and training as jobs change. For example, based on the chart above, an insulation installer may benefit from increased employment opportunities as homeowners and commercial building owners pursue weatherization projects to make buildings more energy efficient. Though insulation products will evolve and improve over time, the jobs tasks and skills required probably will not change substantially. In contrast, a green plumber (who can be found in the “green enhanced skills category”) will need to additional training such as how to work with solar hot water heaters or new water-efficient technology. “New and emerging” occupations include solar energy installation managers, solar photovoltaic installers, solar thermal installers and technicians, wind turbine service technicians, and weatherization installers and technicians; some of these workers will need entirely new sets of skills.

---

<sup>55</sup> Simply plugging in employment figures for an occupation category, such as 49-9021.01, Heating/Air Conditioning Mechanics and Installers, is not meaningful in assessing employment in green construction jobs because current data do not distinguish between green and traditional employment.

# D. Green Construction Job Growth

---

## 1. Current and projected employment

There are approximately 7.2 million construction jobs in the U.S.<sup>56</sup> There is no easy way to estimate the percentage of these jobs that are considered “green.” The U.S. Bureau of Labor Statistics and other federal and state databases gather and track data for the construction industry but none of these sources currently distinguishes between green and traditional construction jobs when collecting data. Furthermore, as discussed above, different researchers and analysts define “green” in different ways, making it difficult to compare numbers across studies. The Bureau of Labor Statistics recently issued a notice of solicitation of comments regarding the collection of new data on green jobs and the definition of green jobs.<sup>57</sup> This is an important step forward in systematically collecting data to understand the trends and outlook for green jobs.

First, to put green construction jobs in the context of green jobs in general, a study by the American Solar Energy Society study estimates that green jobs (defined as renewable energy and energy efficiency jobs and including both direct and indirect jobs), will grow from 8.5 million in 2006 to anywhere from 16 million to 40 million.<sup>58</sup> These numbers have been questioned as being too high.<sup>59</sup> This particular study did not provide growth projections specifically for the green construction industry.

There are some attempts in the existing literature to pin down the number of green construction jobs. A recent study commissioned by the U.S. Green Building Council (USGBC) and prepared by Booz Allen Hamilton estimates that, in a *nine* year period from 2000 to 2008, a total of 1,039,177 jobs were directly attributable to green building.<sup>60</sup> In this study, “green” was defined as LEED projects as well as other projects with numerous green building elements across several categories.<sup>61</sup> On average, this translates into approximately 115,000 green construction jobs per year. This USGBC study

---

<sup>56</sup> U.S. Bureau of Labor Statistics, *Table 5. Employment by Major Occupational Group, 2008 and Projected 2018* (2008).

<sup>57</sup> Notice of Solicitation of Comments, 75 Federal Register 12571 (March 16, 2010).

<sup>58</sup> Roger Bezdek, *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century* (Management Information Services for the American Solar Energy Society, 2007).

<sup>59</sup> United Nations Environment Programme, *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World*.

<sup>60</sup> U.S. Green Building Council and Booz Allen Hamilton, *Green Jobs Study* (2009). The following sectors are included in the estimates: Nonresidential construction (NAICS code: 236200); Residential construction (NAICS code: 236100); Electric power generation, transmission, and distribution (NAICS code: 221100); Water, sewage, and other water treatment systems (NAICS code: 221300); and Waste management and remediation services (NAICS code: 56200). These numbers do not include jobs that are indirectly attributable to green building such as steel and lumber companies that supply materials. See U.S. Green Building Council and Booz Allen Hamilton, *Green Jobs Study*.

<sup>61</sup> U.S. Green Building Council and Booz Allen Hamilton, *Green Jobs Study*.

projects that, in a *five* year period from 2009-2013, a total of 3,340,085 green building jobs will be created,<sup>62</sup> or roughly 668,000 jobs per year.<sup>63</sup>

Other studies look at one component of the green construction sector. In one study commissioned by the American Solar Energy Society, the energy efficiency sector alone yielded 227,000 construction jobs in 2006.<sup>64</sup> This number does not include green construction jobs related to renewable energy generation, installing water-conservation devices, etc. Even so, this figure of 227,000 is almost double the USGBC estimate of 115,000 green construction jobs per year.

Another study prepared for the U.S. Conference of Mayors focused on the retrofitting or weatherization of buildings. This study estimates that, over thirty years, the project to retrofit existing residential and commercial buildings will create almost 81,000 jobs.<sup>65</sup> This includes 36,000 jobs in the residential sector and 45,000 in the commercial sector.<sup>66</sup> These figures do not include other types of construction work, such as new construction of green buildings, or construction work related to other sectors such as renewable power generation.

Although the different figures in the above studies do not neatly line up, the overall expectation is that green construction jobs will surely increase in coming years. It is important to note, though, that some of the green construction jobs may not be entirely new jobs but ones that have been converted from traditional to green. Thus, some of the growth may not be “real.”<sup>67</sup> For example, some pavement jobs are being converted to environmentally friendly permeable concrete jobs but are not actually new jobs.<sup>68</sup>

Looking at job growth at the occupational level can also be difficult. Again, there is very little data on growth in specific green occupations. Some analysts have highlighted certain occupations as being likely to experience growth. With the recession as a backdrop and the infusion of federal stimulus money (discussed below), weatherization and retrofitting projects will be in great demand as opposed to more expensive project like new construction of commercial buildings.<sup>69</sup> According to Eric Glover, a green building market analyst, “One key area of growth is the green retrofit market. I think it’s possible that if green retrofits/renovations represent 20% to 25% of the market by value by 2015, new green building construction could represent the other 20% to 30%. I believe new non-residential green construction represents about 10% to 12% of the market

---

<sup>62</sup> Ibid.

<sup>63</sup> The authors of this study could not be reached for further analysis and clarification of their figures.

<sup>64</sup> Bezdek, *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century*.

<sup>65</sup> The United States Conference of Mayors and Mayors Climate Protection Center, *U.S. Metro Economies: Current and Potential Green Jobs in the U.S. Economy* (2008).

<sup>66</sup> Ibid.

<sup>67</sup> Anonymous, director of continuing education. Personal interview. February 22, 2010.

<sup>68</sup> Ibid.

<sup>69</sup> Ibid.

now.”<sup>70</sup> Heating, Ventilating, and Air Conditioning (HVAC) operations and maintenance technicians may also see increased demand.<sup>71,72</sup> Installation of energy efficient products, such as energy efficient lighting, will also be an area of growth.<sup>73</sup>

Some of these predictions are echoed by the U.S. Bureau of Labor Statistics (BLS) which does not distinguish between green and traditional jobs. According to BLS, the following construction-related occupations are likely to experience more than 20% growth between 2008 and 2018:

- Construction laborers (26% growth)
- First-line supervisors/managers of construction trades and extraction workers (23%)
- Heating, air conditioning, and refrigeration mechanics and installers (43%)
- Helpers, carpenters (25%)
- Helpers, electricians (26%)
- Insulation workers, mechanical (21%)
- Pipelayers, plumbers, pipefitters, and steamfitters (22%)<sup>74</sup>

Some of this growth may be attributed to green building, some may be due to the fact that the recession caused job levels to dip, and some may be due to completely different factors. Even so, the above list and lists like it are helpful tools in deciding what occupations will need skills training, placement services, and other support.

Trying to pin down the number of green construction jobs is a frustrating exercise that illustrates how far we have to go in defining green jobs in a standard, uniform way and in collecting data. Some states, such as Washington State, have taken the initiative in trying to define green jobs and begin to collect new data to measure green job growth and progress.<sup>75</sup> Having a uniform way to define green construction jobs and collect data across all states will go a long way towards tracking our progress to a new green economy.

## 2. Drivers of green construction job growth

Investments and public policies that promote renewable power and energy efficiency are the major drivers of green construction job growth. Green construction workers will be

---

<sup>70</sup> Sari Krieger, "Half of Non-Residential Buildings Will Be Green by 2015 - Study," *Wall Street Journal* (2010).

<sup>71</sup> White and Walsh, *Greener Pathways: Jobs and Workforce Development in the Clean Energy Economy*.

<sup>72</sup> Anonymous, director of continuing education. Personal interview. February 22, 2010.

<sup>73</sup> Dierdorff and others, *Greening of the World of Work: Implications for O\*Net-Soc and New and Emerging Occupations*.

<sup>74</sup> U.S. Bureau of Labor Statistics, "Table 1.8 2008-18 National Employment Matrix, Industry Employment by Occupation (Construction 230000)," (2008).

<sup>75</sup> Washington State Employment Security Department, *2008 Green Economy Jobs in Washington State* (2009).

needed in the construction and installation of new renewable energy systems, particularly over the long term. The push to make buildings more energy efficient will also drive green construction growth in years to come. Some of the drivers of green construction job growth come in the form of financial incentives to adopt greener measures or construct green buildings. One rule of thumb is that every \$1 million invested creates 8 to 11 jobs.<sup>76</sup> Other drivers of job growth come in the form of new and stricter environmental standards.

The drivers of green job growth are discussed in greater depth elsewhere (see citations below). The following list is a selection of federal and state programs that will help drive the growth of the green construction industry:

- Many states offer financial incentives to adopt renewable energy or energy-efficient technology. Forty-six states offer tax incentives to corporations and residents.<sup>77</sup> Thirty-three states offer loan financing to purchase renewable energy or energy-efficient systems.<sup>78</sup> Twenty-two states and the District of Columbia offer rebate programs to promote solar water heating and solar-powered electricity.<sup>79</sup> California's Million Solar Roofs Plan is an example of a state incentive plan that provides subsidies to homeowners and building owners to install solar electric systems.<sup>80</sup> Public housing projects often qualify for subsidies and grants to install renewable energy technology like solar, and has been a source of growth for many green contractors.<sup>81</sup>
- The federal stimulus bill, American Recovery and Reinvestment Act (ARRA), enacted in February 2009, extends \$21 billion in tax incentives for wind, solar, and other renewable energy manufacturers.<sup>82</sup> ARRA also provides more than \$5 billion towards weatherization of low-income homes which could create as many as 133,345 additional weatherization jobs within 2 years.<sup>83,84</sup> ARRA also invests in energy efficiency upgrades to federal buildings.<sup>85</sup>
- Renewable portfolio standards require that a certain percentage of electricity be generated from renewable sources such as wind, solar, geothermal, hydropower, biomass, and hydrogen. Twenty-nine states and the District of Columbia have

---

<sup>76</sup> White and Walsh, *Greener Pathways: Jobs and Workforce Development in the Clean Energy Economy*.

<sup>77</sup> The Pew Charitable Trusts, *The Clean Energy Economy: Repowering Jobs, Businesses and Investments across America*.

<sup>78</sup> Ibid.

<sup>79</sup> Ibid.

<sup>80</sup> State of California -- Office of the Governor -- Arnold Schwarzenegger, *Press Release: Schwarzenegger Signs Legislation to Complete Million Solar Roofs Plan* (2006).

<sup>81</sup> Anonymous, contractor. Personal interview. March 2, 2010.

<sup>82</sup> The Pew Charitable Trusts, *The Clean Energy Economy: Repowering Jobs, Businesses and Investments across America*.

<sup>83</sup> Ibid.

<sup>84</sup> New York Committee for Occupational Safety and Health, "Are Green Jobs Safe Jobs?"

<sup>85</sup> The White House Task Force on the Middle Class -- Staff Report, *Green Jobs: A Pathway to a Strong Middle Class*.

enacted renewable portfolio standards.<sup>86</sup> For example, California passed a Renewable Portfolio Standards (RPS) in 2002 to require the state to generate 20% of its electricity from renewable energy by 2017.<sup>87</sup>

- There are three major regional initiatives, encompassing twenty-three states, to increase renewable energy generation and reduce carbon emissions from power plants.<sup>88</sup>
- Nineteen states have adopted energy efficiency standards for energy generation, transmission, and use.<sup>89</sup>
- State and local governments have enacted their own programs to encourage green building. Some of these include: Wisconsin Green Built Home; Florida Green Home Designation; City of Scottsdale Green Building Program; New Mexico Building America Partnership; City of Chicago Green Homes Program.<sup>90</sup> California's new building code ("CALGreen"), effective January 2011, will set new standards for water and energy use in new buildings, mandate that 50 percent of construction waste be recycled, and require the use of low-pollutant paints, carpets, and floorings.<sup>91</sup> At the local level, Los Angeles' Green Retrofit and Workforce Program incorporates social justice with environmental goals by retrofitting city buildings in low-income neighborhoods.<sup>92</sup>

It is likely that, in the short term, less costly project like weatherization and retrofitting will be the main driver of green construction growth. Over the long term, as the cost of renewable energy lessens and higher targets are set for renewable portfolio standards, the renewable power sector may begin to take off.

---

<sup>86</sup> The Pew Charitable Trusts, *The Clean Energy Economy: Repowering Jobs, Businesses and Investments across America*.

<sup>87</sup> White and Walsh, *Greener Pathways: Jobs and Workforce Development in the Clean Energy Economy*.

<sup>88</sup> The three initiatives are: Midwestern Greenhouse Gas Reduction Accord; Regional Greenhouse Gas Initiative; and Western Climate Initiative. The Pew Charitable Trusts, *The Clean Energy Economy: Repowering Jobs, Businesses and Investments across America*.

<sup>89</sup> *Ibid.*

<sup>90</sup> Neil Silins, "Leed & the Safety Profession: Green Has Come of Age," *Professional Safety* 54, no. 3 (2009).

<sup>91</sup> Marisa Lagos, "State Adopts Greenest Building Codes in U.S.," *San Francisco Chronicle*, January 13 2010.

<sup>92</sup> Delp and Stewart, *Green Buildings, Good Jobs, Safe Jobs: Social Justice Pathways to a Sustainable Los Angeles*.

## E. Hazards in Green Construction

---

It would appear on the surface that green building should be safe and healthy for everyone, including workers. However, workers are not necessarily safer working on green buildings compared to traditional buildings. In one study of 86 construction projects, it was found that there was little or no difference between LEED and non-LEED projects in terms of construction safety and health, leading to the conclusion that green building are not truly sustainable.<sup>93</sup>

The mere fact of working on a green building project does not guarantee worker safety, as demonstrated by the MGM Mirage's mammoth CityCenter project. The \$8.5 billion project, which features hotels, condos, retail, and entertainment, was awarded LEED certification for six of its facilities.<sup>94</sup> However, during the course of construction on that project, six construction workers were killed.<sup>95</sup> Though it appears that all were engaged in traditional jobs, such as working on an elevator, the bottom line is that certifying a building as green does not necessarily translate into ancillary benefits like increased worker safety. At the end of the day, green certification is still about accumulating points to meet specific goals and cannot be interpreted to mean that building developers, owners, designers, and contractors are necessarily paying special attention to worker health.

While some researchers and occupational safety and health organizations have begun compiling lists of hazards associated with green construction (see citations below), there are very few formal studies aimed at analyzing green construction hazards. One study predicts that, while more research is needed, the occupational injury rate associated with renewable energy is likely to be lower than that of the fossil fuel industry.<sup>96</sup> This study did not, however, focus on construction jobs; it looked more broadly at manufacturing and production jobs. The European Agency for Safety and Health at Work is currently working on a two-year project to identify technological innovations in green jobs that may have occupational health impacts.<sup>97</sup> This is an area that requires more research; the list of hazards below offers a starting point.

---

<sup>93</sup> Sathyanarayanan Rajendran, "Sustainable Construction Safety and Health Rating System" (Oregon State University, 2006).

<sup>94</sup> Amanda Finnegan, "Two More Citycenter Structures Earn High Green Ratings," *Las Vegas Sun*, November 20 2009.

<sup>95</sup> Las Vegas Sun, *Construction Deaths: Fatal Construction Accidents on the Strip* (2010, accessed May 4 2010); available from <http://www.lasvegassun.com/news/topics/construction-deaths/>.

<sup>96</sup> Steven A. Sumner and Peter M. Layde, "Expansion of Renewable Energy Industries and Implications for Occupational Health," *Journal of the American Medical Association* 302, no. 7 (2009).

<sup>97</sup> The European Agency for Safety and Health at Work, (2010, accessed); available from [http://osha.europa.eu/en/teaser/Files/20100525\\_project-overview-for\\_web\\_survey.pdf?utm\\_source=oshmail&utm\\_medium=email&utm\\_campaign=oshmail-96](http://osha.europa.eu/en/teaser/Files/20100525_project-overview-for_web_survey.pdf?utm_source=oshmail&utm_medium=email&utm_campaign=oshmail-96).

It is important to note that many green construction hazards are not entirely new and that some of the above hazards “substitute” for hazards that workers would be exposed to if working in the traditional construction industry.<sup>98,99</sup> Still others point out that the workplace hazards themselves are not new but the context is new.<sup>100</sup> Indeed, the green construction hazards described below do not fall within entirely new categories; they adhere to the traditional categories of hazards: falls, electrical hazards, ergonomic hazards, etc. The compilation of hazards below distinguishes between hazards that may increase in frequency (because of growth in green construction) and hazards that are associated with new technologies and products. Below is a summary of occupational hazards in green construction, followed by a more detailed explanation of each hazard.

**Figure 4: Summary of Occupational Hazards in Green Construction**

<p><b>Increased Risk of Existing Hazards</b></p> <ul style="list-style-type: none"> <li>Skylights: Falls</li> <li>Atriums: Falls</li> <li>Atriums: Ergonomics</li> <li>Recycling: Strains, Sprains, and Punctures</li> <li>Recycling: Slips and Falls</li> <li>Recycling: “Struck-by” Hazards</li> <li>Recycled Materials: Coal Ash in Concrete</li> <li>Weatherization: Lead and Asbestos Exposure</li> <li>Weatherization: Electrical</li> <li>Indoor Air Quality: Heat Stress</li> </ul> <p><b>Hazards Associated with New Technologies and Products</b></p> <ul style="list-style-type: none"> <li>Solar Power: Falls</li> <li>Solar Power: Electrical</li> <li>Solar Power: Exposure to Toxics</li> <li>Solar Power: Burns</li> <li>Solar Power: Ergonomics</li> <li>Wind Power: Falls</li> <li>Wind Power: Electrical</li> <li>Weatherization: Exposure to Isocyanate</li> <li>Weatherization: Exposure to Silica</li> <li>Building Materials: Exposure to Silica</li> <li>Building Materials: Exposure to Nanomaterials</li> </ul>
---

<sup>98</sup> Sumner and Layde, "Expansion of Renewable Energy Industries and Implications for Occupational Health."

<sup>99</sup> Anonymous, union. Personal interview. February 16, 2010.

<sup>100</sup> Anonymous, director of continuing education. Personal interview. February 22, 2010.

## Increased Risk of Existing Hazards

- **SKYLIGHTS: Falls.** Skylights can be an important component of a green building by increasing the amount of natural light into the building and reducing energy use. However, workers installing skylights, or even working near them, can easily fall through them. This is in part because skylights are not built to withstand heavy loads and often do not have guarding. In Texas, an iron worker was installing a new skylight on the roof of a metal structure when he fell through the skylight and was killed.<sup>101</sup> In California, an electrical worker was carrying solar panels when he fell through a skylight and was killed.<sup>102</sup> Workers that are performing maintenance on rooftops with skylights are also at an increased risk of falls. For example, in 2007, a maintenance worker in California was sweeping debris off a skylight when the broom handle broke, causing the worker to lose his balance and fall 17 feet to the floor below; the worker was killed.<sup>103</sup>
- **ATRIUMS: Falls.** Atriums, which bring natural light into a building, are also an important green building feature. Atriums, however, can be several stories high, necessitating the use of extensive scaffolding, which increases the risk of falls.<sup>104,105</sup> The National Occupational Research Agenda (NORA) Construction Sector Council identifies scaffolding as one of the major risk factors associated with falls.<sup>106</sup>
- **ATRIUMS: Ergonomics.** Atriums are sometimes designed with large glass panes that can be heavy and difficult to carry, posing ergonomic risks to workers.<sup>107</sup>
- **RECYCLING: Strains, Sprains, and Punctures.** Some studies have shown that construction material recycling programs can increase the risk of injuries.<sup>108</sup> In order to collect and divide construction waste into separate streams for

---

<sup>101</sup> U.S. Department of Labor Occupational Safety and Health Administration, *Accident Investigation Search, Inspection 307461855, Event Date 12/12/2006*(accessed May 5 2010); available from <http://www.osha.gov/pls/imis/accidentsearch.html>.

<sup>102</sup> California Department of Public Health -- California Fatality Assessment and Control Evaluation (CA/FACE) Program, *California Face Report #09ca003: An Electrical Worker Dies When He Falls through a Skylight While Installing Solar Panels on the Roof of a Warehouse* (2009).

<sup>103</sup> National Institute of Occupational Safety and Health, *Fatality Assessment and Control Evaluation (Face) Program: A Hispanic Maintenance Worker Dies after Falling through a Skylight*(2007, accessed); available from <http://www.cdc.gov/niosh/face/stateface/ca/07CA007.html>.

<sup>104</sup> Rajendran.

<sup>105</sup> Gambatase, Rajendran, and Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health."

<sup>106</sup> National Occupational Research Agenda (NORA) Construction Sector Council, *National Construction Agenda for Occupational Safety and Health Research and Practice in the U.S. Construction Sector*.

<sup>107</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

<sup>108</sup> Rajendran.

recycling, workers must handle two to three times more than usual.<sup>109,110</sup> This could increase the risk of strains, sprains, and punctures. For example, on one green construction project, a worker's foot was punctured by a nail while breaking down a wood pallet for recycling.<sup>111,112</sup> On another major green building project, one laborer who was tasked with separating materials for recycling reported that she had to buy her own steel-toe boots with her own money, and was glad she did because plenty of nails went through her boots but were stopped by the steel plate.<sup>113</sup>

- **RECYCLING: Slips and Falls. “Struck-by” Hazards.** Recycling increases the amount of congestion at the construction site. Multiple dumpsters are used to hold different types of waste and, depending on the layout of the jobsite, could lead to overcrowding and increased risk of accidents such as slips and falls.<sup>114,115</sup> It could also increase the risk of accidents caused by construction vehicles such as forklifts maneuvering in tight spaces. A laborer observed that it could sometimes be difficult to separate materials into five different bins -- metal, paper, wood, plastic, and concrete -- because the worksite was so crowded and congested. He mentioned that the nearby forklifts and nail guns shooting misfired nails made the job that much more hazardous.<sup>116</sup>
- **RECYCLED MATERIALS: Coal Ash in Concrete.** Coal ash, including fly ash, is a byproduct of coal combustion and can contain arsenic, mercury, and other substances.<sup>117</sup> Coal ash is sometimes added to concrete to strengthen concrete as a building material, divert ash from landfills, and conserve the use of cement. The Leadership in Energy and Environmental Design (LEED) rating system awards credits if a project uses recycled content materials such as coal ash.<sup>118,119</sup> Though pouring recycled-content concrete may not pose serious risks,

See Appendix A for the case study of a laborer who was run over by a front-end loader.

---

<sup>109</sup> Ibid.

<sup>110</sup> Gambatese, Rajendran, and Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health."

<sup>111</sup> Rajendran.

<sup>112</sup> Gambatese, Rajendran, and Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health."

<sup>113</sup> Anonymous, laborer. Personal interview. June 14, 2010.

<sup>114</sup> Rajendran.

<sup>115</sup> Gambatese, Rajendran, and Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health."

<sup>116</sup> Anonymous, laborer. Personal interview. June 14, 2010.

<sup>117</sup> U.S. Environmental Protection Agency, *New Release: Epa Announces Plans to Regulate Coal Ash*(2010, accessed May 10 2010); available from <http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/4eca022f6f5c501185257719005dfb1b!OpenDocument>.

<sup>118</sup> If the sum of postconsumer recycled content plus 1/2 of the preconsumer content makes up at least 10% of the total value of materials in the project, the project is awarded one credit. If the sum of postconsumer and preconsumer recycled content makes up at least 20% of the materials,

the grinding or drilling of this concrete could potentially release coal ash dust, thus increasing health risks to workers.<sup>120</sup> The U.S. Environmental Protection Agency is considering whether to regulate coal ash as a hazardous waste though it would still allow the use of coal ash in concrete, wallboard, and other building materials.<sup>121</sup> Recycled materials are also used in other building products, creating a risk of exposure to contaminants that might not be present in new materials.<sup>122</sup> For example, lead could be found in recycled metals and silica could be used in fill.<sup>123</sup>

- **WEATHERIZATION: Lead and Asbestos Exposure.** Energy efficiency retrofitting and weatherization in older buildings could potentially disturb asbestos-containing materials or lead paint.<sup>124</sup>
- **WEATHERIZATION: Electrical.** Knob-and-tube wiring in older homes could potentially expose weatherization workers to electrical hazards during the installation of insulation.<sup>125</sup> Even simply caulking an exterior window or installing insulation on a second story could pose an electrical hazard if the worker is working on scaffolds or rooftops where he or she could be exposed to overhead power lines.
- **INDOOR AIR QUALITY: Heat Stress.** To protect indoor air quality for future occupants, the air supply vents to buildings are sometimes sealed off during construction so that construction dust and any emissions do not enter the building and risk the health of future occupants. However, sealing off air vents and minimizing ventilation could expose construction workers to heat stress.<sup>126,127</sup>

See Appendix A for the case study of a worker who was electrocuted while weatherizing a building.

---

the project is awarded two credits. U.S. Green Building Council, *Leed 2009 for New Construction and Major Renovations*.

<sup>119</sup> Nadine M. Post, *Fly Ash Looms as the 'New Asbestos'*(2010, accessed May 10 2010).

<sup>120</sup> U.S. Environmental Protection Agency, "Using Coal Ash in Highway Construction: A Guide to Benefits and Impacts," (2005).

<sup>121</sup> U.S. Environmental Protection Agency, *New Release: Epa Announces Plans to Regulate Coal Ash*(accessed).

<sup>122</sup> Anonymous, director of continuing education. Personal interview. February 22, 2010.

<sup>123</sup> Ibid.

<sup>124</sup> Rhode Island Committee on Occupational Safety and Health, *Going Green, Safely*.

<sup>125</sup> Labor Occupational Health Program at the University of California at Berkeley, "Safe Green Construction Curriculum," (2010).

<sup>126</sup> Anonymous, professor. Personal interview. March 8, 2010.

<sup>127</sup> U.S. Environmental Protection Agency, *Iaq Design Tools for Schools: Construction*(accessed June 21 2010); available from <http://www.epa.gov/iaq/schooldesign/construction.html>.

## Hazards Associated with New Technologies and Products

See Appendix A for the case study of a solar panel installer who fell through a skylight and died in a fall.

- **SOLAR POWER: Falls.** The increase in the use of rooftop solar panels to capture energy from the sun means that there will be an increase in the amount of foot traffic on rooftops during both construction and maintenance. This could increase the number of falls from rooftops. Falls already account for about one-third of all construction fatalities in the U.S and are the most common cause of death in construction.<sup>128</sup> One solar panel installer observed that often there are not places to easily tie off to, thereby making it difficult to protect against falls.<sup>129</sup> Another solar panel installer witnessed a third installer, who was wearing a harness but was not anchored, fall 10 feet from a ladder; fortunately, the worker fell on a pile of dirt and was not seriously injured.<sup>130</sup> In one recent, tragic example, on April 7, 2010, a worker fell off a roof while installing solar panels in San Pablo, California.<sup>131</sup> Working 43 feet off the ground, the worker was walking backward when he fell off the two-story building and was killed.<sup>132</sup>
- **SOLAR POWER: Electrical.** When working on a building where electrical power comes from both the utility and a solar electrical system, workers need to know that pulling the main breaker shuts off the utility power and not the solar power; workers could still be electrocuted by the solar power system.<sup>133</sup> Unlike a traditional system where the electrician can isolate the load from the power source and then work on the “safed zero energy load,” an electrician working on a solar panel system is working on the power source itself (the panels or the wiring); this is fundamentally different from working on a “safed load.”<sup>134</sup> Working with solar systems on roof tops can also expose workers to the risk of electrocution from nearby power lines. In California, a solar technician was installing a solar hot water tank on the roof of a building when the metal bracket of the hot water tank made contact with a nearby high voltage power line.<sup>135</sup> The worker was electrocuted, fell 35 feet to the

See Appendix A for the case study of a solar technician who was electrocuted and fell to his death.

<sup>128</sup> National Occupational Research Agenda (NORA) Construction Sector Council, *National Construction Agenda for Occupational Safety and Health Research and Practice in the U.S. Construction Sector*.

<sup>129</sup> Anonymous, solar panel installer. Personal interview. May 11, 2010.

<sup>130</sup> Anonymous, solar panel installer. Personal interview. June 15, 2010.

<sup>131</sup> "Opu Issued in Fatal Solar Install," *Cal-OSHA Reporter* 37, no. 15 (2010).

<sup>132</sup> *Ibid.*

<sup>133</sup> Oregon Solar Energy Industries Association, *Solar Construction Safety* (2006).

<sup>134</sup> *Ibid.*

<sup>135</sup> California Department of Public Health -- California Fatality Assessment and Control Evaluation (CA/FACE) Program, *California Face Report #08ca006: Laborer Dies When He Falls 35 Feet from a Scaffold after Being Electrocuted* (2009).

ground below, and died the following day.<sup>136</sup> As solar technologies evolve, new risks could emerge. For example, photovoltaic cells can now be built right into shingles and tiles; it is claimed that roofers can install them without electrical training.<sup>137</sup> While some of these technologies may well be safe, especially if there is no possibility that equipment will be energized, other technologies may need additional training for new categories of workers.

- **SOLAR POWER: Exposure to Toxics.** Solar panel manufacturing uses very hazardous chemicals including silicon dust, cadmium, and selenium dioxide.<sup>138</sup> Under normal circumstances, any hazardous materials that are used to create solar panels are safely encased in the panels. However, in the future, as solar panels are upgraded and aging buildings with solar panels are demolished, workers performing demolition work could potentially be exposed to these hazardous materials. Workers responsible for installation of panels could also be exposed if panels are defective or become damaged during installation.
- **SOLAR POWER: Burns.** Solar panels and solar hot water collectors that have been exposed to sunlight can become very hot and can cause burns.<sup>139</sup>
- **SOLAR POWER: Ergonomics.** Solar panels, especially hot water panels, can measure 4 feet by 10 feet and can be heavy and awkward to lift onto rooftops, thus exposing workers to ergonomic and back injuries.<sup>140</sup> A solar panel installer commented that each panel weighs roughly 25 pounds and that safely lifting a panel onto a roof requires two people on the ground and two people on the roof.<sup>141</sup>
- **WIND POWER: Falls.** Windmills can be several hundred feet tall and can therefore pose a serious fall hazard for construction workers as well as maintenance workers. In one accident in Texas, a worker fell 50 feet inside the shaft of a wind turbine and suffered broken ribs and a leg.<sup>142</sup>
- **WIND POWER: Electrical.** Installing wind turbines could potentially expose workers to electrical current, though maintenance workers and technicians face the greatest risk of electrocution. In Minnesota, a worker suffered a severe electrical burn because the wind

See Appendix A for the case study of a wind technician who was crushed when a wind turbine tower collapsed.

---

<sup>136</sup> Ibid.

<sup>137</sup> Anonymous, trainer. Personal interview. February 10, 2010.

<sup>138</sup> Silicon Valley Toxics Coalition, *Toward a Just and Sustainable Solar Energy Industry* (2009), White Paper.

<sup>139</sup> Oregon Solar Energy Industries Association.

<sup>140</sup> Ibid.

<sup>141</sup> Anonymous, solar panel installer. Personal interview. June 15, 2010.

<sup>142</sup> Sarah Kleiner Varble, "Man Injured after Fall inside Wind Turbine," *Abilene Reporter News*, April 16 2008.

turbine was electrically charged when he was working on it.<sup>143</sup> In Oregon, a wind technician was killed when the energy isolation device on a wind turbine was not properly restored to the operational position after maintenance.<sup>144</sup> When the service brake was released, a blade struck the tower, which collapsed and killed the worker.<sup>145</sup> Although this incident involved maintenance and not construction workers, it underlines the importance of proper procedures for controlling potentially hazardous energy.

- **WEATHERIZATION: Exposure to Isocyanate.** Workers installing insulation to weatherize a house are performing green jobs even though the insulation materials they are using are not necessarily green. Isocyanates are used in polyurethane spray foam insulation and are sometimes used in weatherization projects.<sup>146</sup> Isocyanates are a family of chemicals that can cause asthma, respiratory irritation, and contact dermatitis.<sup>147,148</sup> One NIOSH health hazard study found that construction workers spraying polyurethane foam insulation on a roof were exposed to amounts of 4,4'-Methylene-bisphenyl isocyanate (MDI) that exceeded both the full-shift and short term NIOSH limits.<sup>149</sup> This is an area that has been identified as needing additional worker training.<sup>150</sup>
- **WEATHERIZATION: Exposure to Silica.** Synthetic vitreous fibers are a category of insulating materials that include: glass fibers (or fiberglass), mineral wool, and refractory ceramic fibers.<sup>151</sup> Fiberglass, which is made of silica, can cause eye, respiratory, and skin irritation.<sup>152</sup> Fiberglass fibers can become airborne when insulation is being installed, particularly when insulation is being blown into building cavities or attics.<sup>153</sup> Cutting fiberglass batts to fit around wires and pipes can also expose the fiberglass.<sup>154</sup> Refractory ceramic fiber, which is sometimes used to insulate furnaces, is known to cause cancer and pulmonary fibrosis in animals.<sup>155</sup>

---

<sup>143</sup> Tim Ruzek, "Man Burned While Working on Wind Turbine near Dexter," *Austin Post-Bulletin*, December 17 2008.

<sup>144</sup> Oregon OSHA, *Oregon Osha Releases Findings in Wind Turbine Collapse*(2008, accessed June 8 2010); available from [http://www.orosha.org/admin/newsrelease/2008/nr2008\\_05.pdf](http://www.orosha.org/admin/newsrelease/2008/nr2008_05.pdf).

<sup>145</sup> *Ibid.*(accessed).

<sup>146</sup> Rhode Island Committee on Occupational Safety and Health, *Going Green, Safely*.

<sup>147</sup> Chandran Achutan and Rick Driscoll, *Niosh Health Hazard Evaluation Report: Heta #2004-0038-2966, Us Roofing Contractors* (2005), National Institute of Occupational Safety and Health, *Niosh Safety and Health Topic: Isocyanates* (2010).

<sup>148</sup> National Institute of Occupational Safety and Health, *Niosh Safety and Health Topic: Isocyanates*.

<sup>149</sup> Achutan and Driscoll, *Niosh Health Hazard Evaluation Report: Heta #2004-0038-2966, Us Roofing Contractors*.

<sup>150</sup> Anonymous, union. Personal interview. February 16, 2010.

<sup>151</sup> U.S. Department of Health and Human Services -- Agency for Toxic Substances & Disease Registry, *Toxfaqs for Synthetic Vitreous Fibers* (2004).

<sup>152</sup> *Ibid.*

<sup>153</sup> Build It Green, *"Green" Fiberglass Insulation* (2005).

<sup>154</sup> *Ibid.*

<sup>155</sup> U.S. Department of Health and Human Services -- Agency for Toxic Substances & Disease Registry, *Toxfaqs for Synthetic Vitreous Fibers*.

- **BUILDING MATERIALS: Exposure to Silica.** Fiber cement siding is sometimes used in large commercial construction, in part because it resists mold and mildew and is durable. However, because fiber cement is made up of as much as 30-40% crystalline silica, the cutting and scraping of fiber cement can be hazardous to workers.<sup>156</sup>
- **BUILDING MATERIALS: Exposure to Nanomaterials.** Nanotechnology refers to the engineering and production of materials less than 100 nanometers in at least one dimension. There are more than 50 nanotechnology-based products being used in the construction industry.<sup>157</sup> Nansulate, which is used to coat interior walls and coatings as a way to increase insulation and decrease energy costs, is one example of a nanotechnology-based product.<sup>158</sup> The product is billed as being low in VOC emissions and non-hazardous.<sup>159</sup> The jury is still out on the safety of nanotechnology products, both in terms of human health and environmental health impacts. The properties of nanomaterials -- including how they react with other chemicals and interact with biological systems -- can differ substantially from bulk materials of the same composition.<sup>160</sup> Some nanoparticles can travel throughout the body and lodge in organs and even mitochondria.<sup>161,162</sup> Even those who advocate for the adoption of nanotechnology have sometimes raised safety concerns because nano-sized particles tend to be more easily absorbed by the body than larger particles.<sup>163</sup> Much concern has been raised about the safety of workers who manufacture of nanomaterials such as carbon nanotubes; however, nanoparticles could potentially be released during use of the product as well.<sup>164</sup>

This compilation of hazards shows that green building can be hazardous work, and that construction workers get injured, and some even die, while building the energy-efficient, water-conserving structures that the rest of us enjoy. Though controls for these hazards are not presented here, most of the controls are well-established in the occupational health literature. Some controls are presented in Section F.2, as well as in the case studies under Appendix A.

The risks described above may be even greater for certain types of workers. The National Occupational Research Agenda (NORA) for Construction highlights immigrant

---

<sup>156</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

<sup>157</sup> Becky Brun and Celeste LeCompte, *5 Nanotech Novelties*(2007, accessed May 3 2010); available from <http://www.sustainableindustries.com/greenbuilding/6234871.html>.

<sup>158</sup> *Ibid.*(accessed).

<sup>159</sup> *Nansulate Homeprotect Clear Coat*, (accessed May 3 2010); available from [http://www.nansulate.com/nansulate\\_homeprotect\\_clearcoat.htm](http://www.nansulate.com/nansulate_homeprotect_clearcoat.htm).

<sup>160</sup> Andre Nel and others, "Toxic Potential of Materials at the Nanolevel," *Science* 311 (2006).

<sup>161</sup> *Ibid.*

<sup>162</sup> Thilo Papp and others, "Human Health Implications of Nanomaterial Exposure," *Nanotoxicology* 2, no. 1 (2008).

<sup>163</sup> "Nanotech & Green Building," *Progressive Investor*, no. 49 (2007).

<sup>164</sup> Nel and others, "Toxic Potential of Materials at the Nanolevel."

workers as one of the populations for which there is disproportionate occupational health and safety risk, and points out that Hispanic workers, a rapidly growing population in construction, have higher occupational fatality rates than other workers.<sup>165</sup> Recent immigrant workers are less likely to be unionized, have lower education levels, and tend to be concentrated in lower-paid, more hazardous occupations within the construction industry such as helpers, laborers, and roofers.<sup>166</sup> Construction workers who are not unionized are also more likely to be exposed to higher risk. For example, non-union workers have been observed installing solar panels without wearing hard hats and without having electrical certification.<sup>167</sup> These disproportionate risks faced by immigrant and non-unionized workers shows how far we have to go to make construction jobs green, just, and sustainable.

---

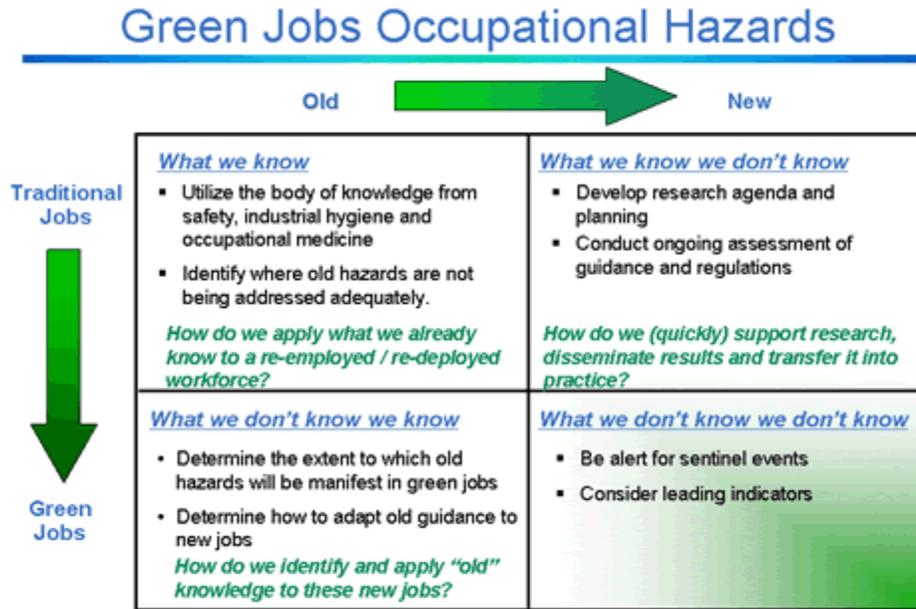
<sup>165</sup> National Occupational Research Agenda (NORA) Construction Sector Council, *National Construction Agenda for Occupational Safety and Health Research and Practice in the U.S. Construction Sector*.

<sup>166</sup> Ibid.

<sup>167</sup> Anonymous, union. Personal interview. March 22, 2010.

The National Institute for Occupational Safety and Health (NIOSH) provides a helpful tool for thinking about hazards associated with new, green jobs and how to address them (see Figure 5, below):

**Figure 5: Dealing with Uncertainty and Green Job Hazards** <sup>168</sup>



The above matrix offers a set of strategies to address both old and new hazards as we make the transition from traditional jobs to green jobs. For many of the hazards in Figure 5, we need to re-visit existing laws, regulations, and policies to evaluate whether they need to be updated to address green construction hazards. For other hazards that are still very uncertain (e.g., the use of nanomaterials) in green building products, we need to be alert for sentinel events. We may, in fact, need to go further to put protections in place (e.g., training, clearer warning labels, respiratory protections) to prevent health impacts that may not appear for many years.

Though some of the hazards compiled above are ones that construction workers would also face in the traditional, “non-green” industry, taken together, the hazards above do pose a risk to green construction workers and point to a need for those in the occupational safety and health community to continue to push to the green jobs movement to recognize and address worker hazards. The rapidly evolving nature of green building products and techniques requires us to be ever vigilant in detecting and addressing new hazards before they become persistent and in acting quickly to eliminate existing hazards that we already know about and have the tools to address.

<sup>168</sup> National Institute for Occupational Safety and Health, *Niosh Safety and Health Topic: Prevention through Design: Green, Safe and Healthy Jobs*(accessed November 15 2009); available from <http://www.cdc.gov/niosh/topics/PtD/greenjobs.html>.

## **F. Recommendations:**

---

To address the hazards that are associated with green construction, we will need a range of different solutions. Some of these solutions involve social messaging and communications coupled with training for owners, designers, contractors, and workers. Others involve policy changes needed to support Prevention through Design efforts, an important way of addressing the underlying causes of construction injury and illness. Other strategies focus on improving voluntary programs, such as green building rating programs and other tools that can be used to promote construction safety.

### **1. Incorporate worker health into the green jobs debate**

The ultimate goal is to build public awareness so that when people think of green jobs, they are thinking not just of narrowly defined environmental issues but are asking what makes those jobs decent, safe, and just. By doing so, we set the stage for making structural changes in the way green rating systems are designed, the way funding is distributed to support green jobs creation, and the way laws and regulations are written to define and protect green jobs. We need to raise these issues in a way that supports the green jobs movement. After all, those in the occupational safety and health community are very much in support of transitioning to a green economy.

By addressing these larger questions of sustainability (including the environmental, economic, resource, and social aspects), the green jobs movement can build deeper alliances with the many other communities that could be useful partners in furthering green jobs goals. The Blue-Green Alliance, which has brought together the environmental and labor movements, is a good example of how the green jobs movement is already building these partnerships. The success of groups like the Apollo Alliance and Green for All in bringing attention to green jobs as a way to bring people out of poverty also speaks to the ability of the green jobs movement to adapt and grow.

Redefining “green jobs” to include worker health and safety is one important way of helping to shape the public debate about green jobs. If those in the green jobs community began adopting a definition of green jobs with a worker health component, we might begin to see green jobs policies, green rating systems, funding, and training programs start to change their focus to include worker health. Given that the definition of green jobs is evolving, we still have an opportunity to shape the debate.

To do this, the occupational health community needs to hold individual meetings with major players in the green jobs movement (*see* Figure 6 on Page 43 for a selection of organizations we need to influence), in addition to continuing to actively participate and develop a strong presence in conferences such as Good Jobs, Green Jobs (held by the BlueGreen Alliance Foundation) and GreenBuild by submitting workshop ideas and getting worker health issues on the agenda. We also need to participate in local and regional green jobs coalitions. For example, one organization has played an important role in getting a large group of stakeholders to incorporate occupational safety in its roadmap of a major green jobs plan at the city level.<sup>169</sup> We need to do this at every level, and encourage green jobs advocates and organizations to go one step further by including health and safety in the discussion.<sup>170</sup> We also need to give positive feedback to groups that do build worker health into their conception of green jobs. We need to shift the dialogue now -- “the green economy hasn’t hit yet... there’s still time.”<sup>171</sup> Please see Figure 6 on Page 43 and continue reading this first recommendation on page 44.

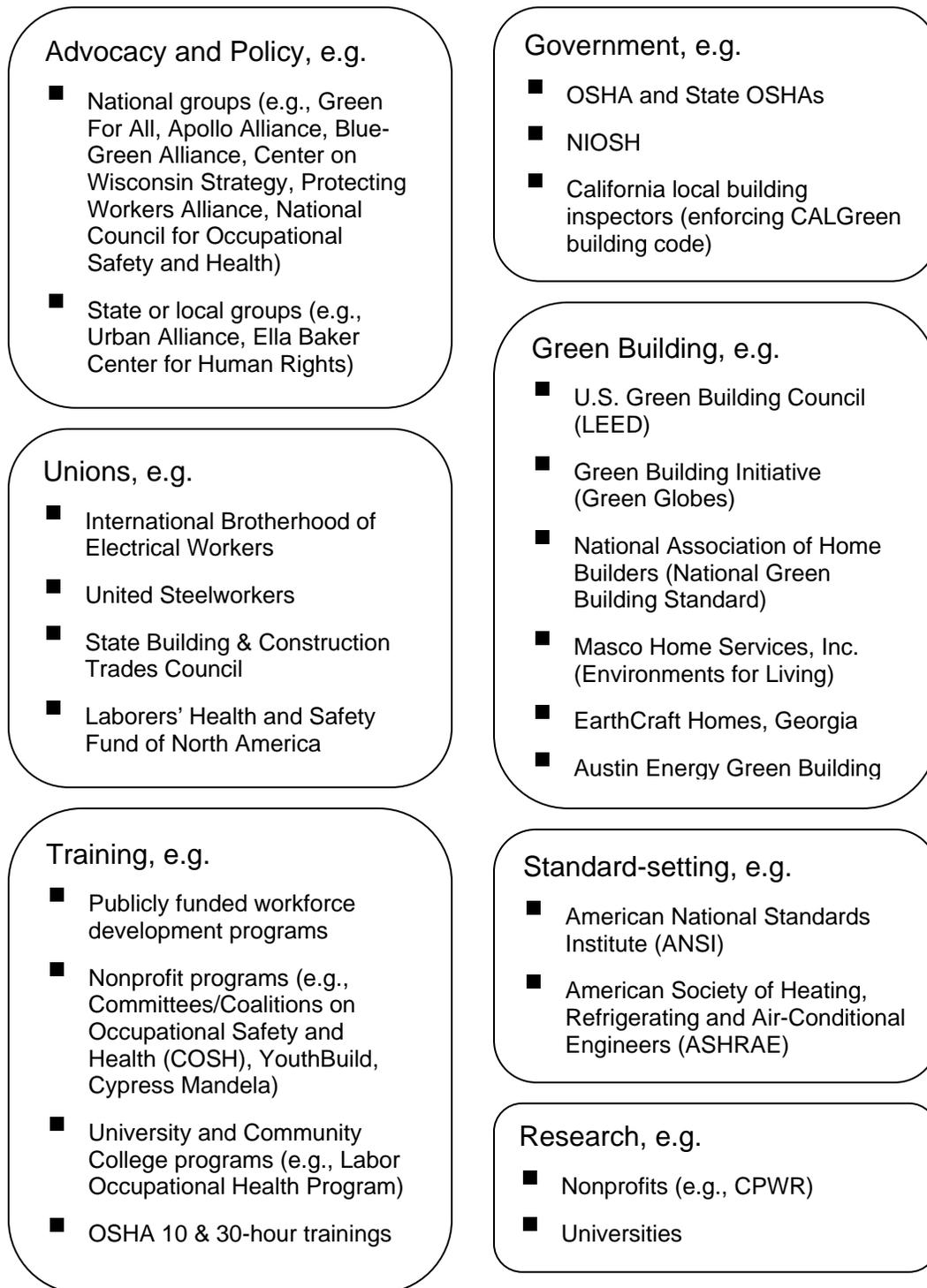
---

<sup>169</sup> Anonymous, occupational health and safety organization. Personal interview. June 14, 2010.

<sup>170</sup> Anonymous, union. Personal interview. March 22, 2010.

<sup>171</sup> Anonymous, union. Personal interview. March 22, 2010.

Figure 6: Types of Organizations Impacting Green Construction Jobs <sup>172,173</sup>



<sup>172</sup> Jones.

<sup>173</sup> Delp and Stewart, *Green Buildings, Good Jobs, Safe Jobs: Social Justice Pathways to a Sustainable Los Angeles*.

Changing the definition of green jobs to include worker health and safety criteria would be an important symbol of how far the green jobs movement goes in embracing the importance of protecting worker health. But this is not the only outcome that we would be satisfied with. If we can change the dialogue around green jobs to include broader sustainability goals including worker health, even without changing the accepted definition of green jobs, then we will have also met our goal of raising public awareness about green job hazards. We need not be caught up in the semantics of the definition of green jobs so long as we can achieve our ultimate goal of raising public awareness and institutionalizing worker health as a part of green jobs and green building programs.

Before we can do any of this, we face a more immediate task of building basic awareness of green jobs hazards. We need to share what we know in the occupational safety and health community: that a wave of new jobs -- in mining, in computer use, in electronics manufacturing -- typically brings with it a host of new occupational hazards. We have the tools to address many of the new hazards we see in green construction though we still have a ways to go in developing the conditions to support other important strategies like Prevention through Design (see discussion below).

The list of green construction job hazards in Section E is a good starting point that could be used by organizations to raise awareness about hazards. We will need to explore ways to package this information so that it sends a clear message that green jobs should not be assumed to be safe jobs; we need to *make* them safe. The National Construction Research Agenda (NORA) also offers many concrete suggestions for how to engage the media to raise awareness about construction safety and health.<sup>174</sup>

We need to encourage workers who have experienced injuries or illnesses as a result of their work on green construction jobs to widely share their stories. One example is the Domestic Worker Safety and Dignity Project which is using social marketing and media strategies to transform the working conditions as well as the perception of domestic work from undervalued women's work to a respected component of the economy.<sup>175</sup> For construction workers, we need to expose the social and emotional cost of injuries including the impact on family relationships and the stress of having to navigate a flawed workers' compensation system.<sup>176</sup> For example, the *Las Vegas Sun* newspaper, which has closely followed the many construction worker deaths that have occurred on the Las Vegas Strip in the last few years, has an interactive tool on their website that summarizes the cause of death (with illustrations showing how the incident happened), the outcome of OSHA investigations, and pictures and biographies of the workers who were killed.<sup>177</sup> These stories are difficult to read but they are an effective wake-up call and could be used as a catalyst for action.

---

<sup>174</sup> National Occupational Research Agenda (NORA) Construction Sector Council, *National Construction Agenda for Occupational Safety and Health Research and Practice in the U.S. Construction Sector*.

<sup>175</sup> This is a project of the Labor Occupational Health Program at the University of California at Berkeley, La Raza Centro Legal, and Underground Advertising.

<sup>176</sup> Anonymous, professor. Personal interview. March 8, 2010.

<sup>177</sup> Las Vegas Sun, *Construction Deaths: Fatal Construction Accidents on the Strip*(accessed).

At the same time, we need to continue to work on developing hazard controls for each of the green construction hazards that we identify. Some of these hazard controls will be more ambitious (such as those described in the Prevention through Design recommendations below). Others will be stopgap solutions that can hold us until we can develop the long-term solutions that get at the underlying causes of injuries and illnesses. As new hazards are identified along with accompanying controls, the occupational health and safety community needs to be ready to share and disseminate what we know. The Construction Solutions database, developed by CPWR — The Center for Construction Research and Training, could, for example, be updated with new green building hazards and control measures.<sup>178</sup>

Creating awareness about green construction safety is one of our most important tasks as it will pave the way for many of the other strategies and recommendations that are described below.

## 2. Promote Prevention through Design

Preventing injuries and illnesses through architectural and/or engineering design, or in NIOSH's language, Prevention through Design (PtD), is the gold standard for promoting construction safety.<sup>179</sup> This is a concept that builds on the principle that, in the hierarchy of controls, engineering controls that eliminate or "design out" hazards are, on balance, superior to adopting safe work practices and procedures and using personal protective equipment. PtD alone will not prevent all construction injuries and illnesses but will go a long way toward creating the conditions for a safe workplace. While the PtD concept is not new, the emergence of green building and the current focus on green design provides an opportunity to also look at *safe* design. This is a growing area of research and analysis; this paper provides a summary of issues that are covered with much greater richness elsewhere.<sup>180</sup>

One important area of research in this field is linking construction injuries and illnesses to building design. One study found that, of 224 construction fatalities, design was linked to the incident in approximately 42% of the cases.<sup>181</sup> For example, in one construction fatality a worker laying insulation fell backwards off a flat roof. Two design elements that would have reduced the risk of a rooftop fall include designing the parapet to be 42

---

<sup>178</sup> CPWR - The Center for Construction Research and Training, *Construction Solutions Database*(accessed); available from <http://www.cpwrconstrutionsolutions.org/>.

<sup>179</sup> National Institute of Occupational Safety and Health, *Niosh Safety and Health Topic: Prevention through Design*(accessed); available from <http://www.cdc.gov/niosh/topics/ptd/>.

<sup>180</sup> See citations below as well as: National Occupational Research Agenda (NORA) Construction Sector Council, *National Construction Agenda for Occupational Safety and Health Research and Practice in the U.S. Construction Sector*.

<sup>181</sup> Michael Behm, "Linking Construction Fatalities to the Design for Construction Safety Concept," *Safety Science* 43, no. 8 (2005).

inches tall to provide guardrail protection and designing attachments or holes near elevated work areas that could permanently supports lifelines and guardrails.<sup>182</sup>

There are numerous examples of design elements that eliminate or greatly reduce the risk of construction hazards. For example, the following is a selection of design recommendations for addressing specific types of fall hazards:

- Place mechanical equipment, such as air conditioning units, at ground level instead of on rooftops whenever possible.<sup>183,184</sup>
- Design multiple, permanent roof anchors that workers can tie off to.<sup>185,186</sup>
- Specify parapet walls on roofs to be 39” to 42” high to serve as a guardrail.<sup>187,188</sup>
- Specify skylights that can withstand a load of 200 pounds or more; or, design skylights with permanent guardrails.<sup>189,190</sup>
- Place light fixtures in areas that are more accessible for both construction and maintenance workers.<sup>191</sup>

These are just some examples of possible hazard controls that can minimize the risk of construction injuries. In developing and refining new design concepts, architects and engineers should obtain input from construction workers and contractors so that designers have the best available information about how work is performed.

## Challenges: Cost

There are numerous challenges that make it difficult for architects and engineers to proactively design out safety hazards. The upfront costs of designing for safety can be a significant concern. These include increased capital costs, as well as the maintenance costs.<sup>192</sup> It may be difficult to persuade banks to provide loans that can cover these

---

<sup>182</sup> Ibid.

<sup>183</sup> Anonymous, union. Personal interview. February 16, 2010.

<sup>184</sup> OSHA Alliance Program -- Construction Roundtable, *Construction Workplace Design Solution: Falls from Roof Edge*(2010, accessed 2010 May 24); available from [http://www.designforconstructionsafety.org/Documents/DS1%20-%20Falls%20From%20Roof%20Edge%20\(JM%20update%204-23-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS1%20-%20Falls%20From%20Roof%20Edge%20(JM%20update%204-23-10).pdf).

<sup>185</sup> Anonymous, union. Personal interview. February 16, 2010.

<sup>186</sup> OSHA Alliance Program -- Construction Roundtable, *Construction Workplace Design Solution: Falls from Roof Edge*(accessed).

<sup>187</sup> Anonymous, union. Personal interview. February 16, 2010.

<sup>188</sup> OSHA Alliance Program -- Construction Roundtable, *Construction Workplace Design Solution: Specify Sufficient Wall Height to Allow Parapets to Function as Fall Prevention*(2010, accessed May 24 2010); available from [http://www.designforconstructionsafety.org/Documents/DS6%20-%20Parapets%20\(MG-TB%20update%205-3-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS6%20-%20Parapets%20(MG-TB%20update%205-3-10).pdf).

<sup>189</sup> Gambatase, Rajendran, and Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health."

<sup>190</sup> OSHA Alliance Program -- Construction Roundtable, *Construction Workplace Design Solution: Specify Non-Fragile Skylights and/or Skylight Guards*(2010, accessed May 24 2010); available from [http://www.designforconstructionsafety.org/Documents/DS5%20-%20Skylight%20\(MG-TB%20update%205-3-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS5%20-%20Skylight%20(MG-TB%20update%205-3-10).pdf).

<sup>191</sup> Anonymous, union. Personal interview. February 16, 2010

<sup>192</sup> Anonymous, industrial hygienist. Personal interview. March 3, 2010.

additional costs.<sup>193</sup> On the other hand, decreased workers' compensation costs, increased productivity, and other economic benefits may offset some of these costs. Advocates for PtD have long tried to make the business case for worker safety, though more case studies are needed.<sup>194</sup> We need to continue to quantify the economic value of health and safety interventions to make our strongest case for safety. At the same time, fine-tuning the economic argument is only part of the battle -- investing in worker safety *will* sometimes have a substantial price tag and we need to push for a cultural shift in which the safety and well-being of workers is a priority (more on this below).<sup>195</sup>

## **Challenges: Liability**

Under most arrangements, the owner contracts with the designer to design the plans for the building, contractors bid on the project based on the design, and then the contractor who is awarded the bid builds the project.<sup>196</sup> It is said that the contractor controls the "means and methods" of construction, which is often interpreted to mean that worker safety falls within the responsibility of the contractor and the contractor only. Architects are not covered by workers' compensation insurance with respect to construction workers and do not want to be perceived as having control over the workplace.<sup>197</sup> Designers are perceived as being one step removed from worker safety<sup>198</sup> and therefore not responsible for worker safety.

One study has looked at legal precedents and found a handful of cases that have held architects liable for actions (or inaction) that resulted in construction injuries.<sup>199</sup> There is also some research being conducted in this area to look at the degree to which architects in other countries may have a duty of care to workers.<sup>200</sup> For example, in the UK, under the Construction Design Management (CDM) regulations, designers are required to reduce risks and eliminate hazards to construction worker safety in the design as well as provide information about remaining hazards.<sup>201</sup>

This is an area that needs further research<sup>202</sup> and where policy change may be necessary to define the roles, responsibilities, and liability of designers, and to make it clear that designers are not telling contractors how to construct but are trying to help contractors do their job safely.<sup>203</sup> Tools need to be developed to better enable designers to incorporate

---

<sup>193</sup> Anonymous, union. Personal interview. February 16, 2010.

<sup>194</sup> Anonymous, professor. Personal interview. March 8, 2010.

<sup>195</sup> Anonymous, professor. Personal interview. March 10, 2010.

<sup>196</sup> Behm, "Linking Construction Fatalities to the Design for Construction Safety Concept."

<sup>197</sup> Anonymous, director of continuing education. Personal interview. February 22, 2010.

<sup>198</sup> Anonymous, professor. Personal interview. March 10, 2010.

<sup>199</sup> Michael Behm, "Legal and Ethical Issues in Designing for Construction Safety and Health," in *Designing for Safety and Health in Construction*, ed. Steven Hecker, John Gambatese, and Marc Weinstein (Portland, Oregon: 2003).

<sup>200</sup> Anonymous, professor. Personal interview. March 8, 2010.

<sup>201</sup> "The Construction Design and Management Regulations, Part 2, Section 11.," (2007).

<sup>202</sup> See National Occupational Research Agenda (NORA) Construction Sector Council, *National Construction Agenda for Occupational Safety and Health Research and Practice in the U.S. Construction Sector*.

<sup>203</sup> Anonymous, professor. Personal interview. March 10, 2010.

PtD concepts. One example is to devise model contract language that does not inappropriately shift safety duties onto designers.<sup>204</sup>

### **Challenges: Educate designers about construction worker safety**

Architects and engineers are trained on how to protect the safety of occupants and how to comply with building codes but are often not trained on how to protect the safety of construction workers.<sup>205,206,207</sup> As one example, an occupational safety and health expert was explaining during a workshop that fiber cement panels contain crystalline silica which can be released when the panels are cut. An architect present at the workshop said that it hadn't even occurred to him to consider what fiber cement was made of and to consider the safety of the product.<sup>208</sup> Designers need to be trained to ask these questions as the first step to designing for construction safety.

One 2003 study found that while civil engineering programs typically do offer at least one course in construction safety, only a very small percentage of programs cover safety in design as a topic.<sup>209</sup> Designing for construction safety is even less likely to be taught in architecture programs. Since accreditation drives curriculum, widespread teaching of construction safety would need to start with changes in accreditation requirements, and would need to be supported by experienced faculty, course materials, case studies, and simulation tools.<sup>210</sup> Another approach is for occupational safety and health professionals to make a concerted effort to offer construction safety trainings to architects and engineers, and some professionals have expressed interest in this area,<sup>211</sup> though other legal, economic, and cultural barriers must be overcome before designers are likely to begin designing for construction safety. Some additional ideas with respect to training are presented in Section F.4 of this report.

### **Challenges: Cultural**

One significant challenge is that, in the United States, there are cultural barriers to prioritizing the safety of construction workers, or, for that matter, any other type of worker. The general public may view workers as belonging to a lower socio-economic class and may think construction safety is not relevant because "it's not me... it's not my next door neighbor."<sup>212</sup> Furthermore, since growing numbers of construction workers are

---

<sup>204</sup> Design for Construction Safety, *Prevention through Design* (accessed 2010 May 18); available from <http://www.designforconstructionsafety.org/media.shtml>.

<sup>205</sup> Anonymous, industrial hygienist. Personal interview. March 3, 2010.

<sup>206</sup> Anonymous, professor. Personal interview. March 10, 2010.

<sup>207</sup> Anonymous, industrial hygienist. Personal interview. April 5, 2010.

<sup>208</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

<sup>209</sup> John Gambatese, "Safety Emphasis in University Engineering and Construction Programs," in *Designing for Safety and Health in Construction*, ed. Steven Hecker, John Gambatese, and Marc Weinstein (Portland, Oregon: 2003).

<sup>210</sup> John Gambatese and Steve Hecker, "Collaboration in Design to Promote Construction Safety," in *14th Annual Construction Safety & Health Conference & Exposition* (Rosemont, IL: 2004).

<sup>211</sup> Anonymous, industrial hygienist. Personal interview. April 5, 2010.

<sup>212</sup> Anonymous, professor. Personal interview. March 8, 2010.

of Latino descent, there may be a racial barrier as well. This means that owners, designers, and lenders alike may not be willing to invest in construction safety.

Tackling these cultural, class, and racial issues can be quite difficult, and cannot fully be explored here. Entire movements -- the environmental justice movement, human rights, social justice, civil rights, workers' rights -- are built around, at one end, changing the pervasive world view and, at the other end, developing leadership in and mobilizing communities to exercise self-determination while correcting injustices. Projects like the Domestic Worker Safety and Dignity Project described above in Section F.1 can go a long way towards transforming both our perceptions of workers as well as actual working conditions. Encouraging workers to tell their own stories is an essential part of generating the empathy and cultural change necessary to prioritize worker health.

Though these challenges seem daunting, there are significant inroads being made. As one example, the American Society of Safety Engineers (ASSE) is developing new standards to protect the safety and health of workers involved in construction and demolition operations for wind generation/turbine facilities,<sup>213</sup> and recently announced a new initiative to develop PtD guidelines.<sup>214</sup>

Taking a closer look at the design-build model may also yield important insights about how to promote worker safety. Design-build refers to a system in which the designer and builder are housed within the same entity, thereby enabling better integration and communication than the traditional design-bid-build relationship. Design-build firms typically have better safety records than traditional construction firms. In one study, the OSHA recordable injury rate (the total number of OSHA recordable injuries occurring for every 200,000 work hours or TRIR) was 0.69 for design-build firms and 1.68 for traditional construction firms.<sup>215</sup> In design-build firms, the builder is engaged in the design process early on in the project when there are more opportunities to influence construction safety.<sup>216</sup> Design-build firms also may be more likely to take worker safety into account because it is their own employees whose safety is at stake. Finding ways to encourage design-build as a project delivery method could be challenging. However, promoting ideas like "best value" contracting could make design-build bids more attractive in the context of a public works project.<sup>217</sup> At the very least, we should strive to find opportunities to insert construction safety in the early design phase of every construction project.

---

<sup>213</sup> American Society of Safety Engineers, *The American Society of Safety Engineers Announces New Standard Project to Protect Workers in Wind Generation Construction Operations*(2009, accessed June 9 2010); available from <http://www.asse.org/newsroom/release.php?pressRelease=1185>.

<sup>214</sup> American Society of Safety Engineers, *ASSE Launches Prevention through Design Initiative, Holds Feb. Webinar*(2010, accessed June 9 2010); available from <http://www.asse.org/newsroom/release.php?pressRelease=1384>.

<sup>215</sup> Xinyu Huang and Jimmie Hinze, "Owner's Role in Construction Safety," *Journal of Construction Engineering and Management* 132, no. 2 (2006).

<sup>216</sup> Greg Baker and Anthony Barsotti, "Procurement Methods to Facilitate Designing for Safety and Health," in *Designing for Safety and Health in Construction*, ed. Steven Hecker, John Gambatese, and Marc Weinstein (Portland, Oregon: 2003).

<sup>217</sup> Ibid.

In some ways, the wave of green building, with its emphasis on “good design,” presents a unique opportunity to take the Prevention through Design concept to the next level. Designers that are now educated about designing for the environment may be more open to designing for worker safety. Now may be the time to forge stronger alliances between the design community and the occupational safety and health community. While the challenges described above are significant, there is no other tool in our bag of tricks that will do more to eliminate hazards at their source than PtD.

### **3. Incorporate worker health into green building certification programs**

Green building certification and rating programs have succeeded not only in mitigating the environmental impact of buildings but have also done much to raise public awareness about alternative energy systems, water conservation techniques, how materials are used in buildings and where those materials come from, and what becomes of demolition debris. It is no wonder that many in the occupational health community have reacted with envy (“If only we had something like this for worker health!”) and sometimes with indignation (“Can a building be truly ‘green’ if the workers who build it get injured or even die in the process?”). The challenge in the occupational health community is to find ways to elevate worker health as a priority either by having existing green rating systems integrate occupational health criteria or by creating other tools that measure and/or predict construction safety. The National Institute for Occupational Safety and Health (NIOSH), for example, has recommended that worker health measurements be added to green benchmarks like the Leadership in Energy and Environmental Design (LEED) rating system.<sup>218</sup>

Critics of this approach sometimes argue that existing occupational safety and health laws and regulations are already in place and that there is no need for a green rating system to incorporate worker health.<sup>219,220,221</sup> However, as discussed in Section B of this report, occupational safety and health violations occur all the time without adequate enforcement by OSHA. Certifying buildings as both environmentally sound and safe for construction workers would create additional layers of “review.” Instead of assigning construction safety just to the contractor, rather, the owner, designer, and even an independent third party (certified rater) would need to review and sign off on different aspects of construction safety.

Below is a discussion of possible ways to integrate worker health criteria into the LEED and other rating systems, a summary of a possible stand-alone rating system that would certify buildings solely based on worker health criteria, and a quick glance at scorecards and other tools that could be used to evaluate construction safety.

---

<sup>218</sup> Gillen, Check, and Branche, *Niosh Science Blog: Going Green: Safe and Healthy Jobs*(accessed).

<sup>219</sup> Anonymous, union. Personal interview. March 22, 2010.

<sup>220</sup> Anonymous, industrial hygienist. Personal interview. April 5, 2010.

<sup>221</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

## a. LEED

One idea is to incorporate worker health and safety criteria into the Leadership in Energy and Environmental Design (LEED) rating system.<sup>222,223</sup> Developed by the U.S. Green Building Council, LEED is a green building certification system that sets voluntary standards for environmental performance. LEED points are awarded (up to a maximum of 100 points) based on a building's performance in the following areas: Sustainable Sites; Water Efficiency; Energy and Atmosphere; Materials and Resources; Indoor Environmental Quality; Location and Linkages; Awareness and Education; Innovation in Design; and Regional Priority.<sup>224</sup>

It has been observed that only one of the above areas has a close connection to construction worker health and safety, and that is indoor environmental quality, or indoor air quality (IAQ).<sup>225</sup> Within the scope of IAQ, the 2009 LEED Rating System for new construction allocates several credits for practices that explicitly protect construction worker health and safety:

- Indoor Environmental Quality Credit 3.1, "Construction Indoor Air Quality Management Plan -- During Construction," awards one point for developing and implementing an IAQ management plan that protects both construction workers and building occupants.<sup>226</sup> This includes meeting or exceeding guidelines set out by the Sheet Metal and Air Conditioning National Contractors Association (SMACNA).<sup>227</sup>
- Indoor Environmental Quality Credit 3.2, "Construction Indoor Air Quality Management Plan -- Before Occupancy," awards one point for either installing filtration media to flush out any contaminants or conducting air sampling after construction ends but prior to occupancy.<sup>228</sup> This will likely have minimal impact on construction worker health because most, if not all, of the construction will already have been completed at this point.
- Indoor Environmental Quality Credit 4.1, "Low-Emitting Materials -- Adhesives and Sealants," awards one point for using adhesives, sealants, and sealant primers that emit fewer volatile organic compounds (VOCs), thereby protecting installers and occupants.<sup>229</sup>

---

<sup>222</sup> Gambatese, Rajendran, and Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health."

<sup>223</sup> Gillen, Check, and Branche, *Niosh Science Blog: Going Green: Safe and Healthy Jobs*(accessed).

<sup>224</sup> U.S. Green Building Council, *Intro - What Leed Measures*(accessed February 1 2010); available from <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1989>.

<sup>225</sup> Gambatese, Rajendran, and Behm, "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health."

<sup>226</sup> U.S. Green Building Council, *Leed 2009 for New Construction and Major Renovations*.

<sup>227</sup> Ibid.

<sup>228</sup> Ibid.

<sup>229</sup> Ibid.

- Indoor Environmental Quality Credit 4.2, “Low-Emitting Materials -- Paints and Coatings,” awards one point for using low-VOC paints and coatings, thereby protecting installers and occupants.<sup>230</sup>
- Indoor Environmental Quality Credit 4.3, “Low-Emitting Materials -- Flooring Systems,” awards one point for using low-VOC flooring materials.<sup>231</sup>
- Indoor Environmental Quality Credit 4.4, “Low-Emitting Materials -- Composite Wood and Agrifiber Products,” awards one point for using composite wood and agrifiber products (such as particleboard) that do not contain added urea-formaldehyde resins.<sup>232</sup>

Together, these credits represent an important step forward in protecting construction worker safety and health. Obviously, they are not alone sufficient to protect worker health.

Adding comprehensive worker health and safety criteria to the LEED rating system would be difficult, though elements from the proposed Sustainable Construction Safety and Health Rating System, described below, could be folded into LEED. Perhaps a more feasible approach would be to prioritize among construction hazards, such as the Focus Four hazards identified by OSHA (falls, electrical hazards, struck-by hazards, and caught-in-between hazards), and build specific protections for the Focus Four hazards into the LEED system.

Another approach would be to work within the current LEED programmatic areas, and make smaller, but still significant, changes to those areas. For example, the section, Materials and Resources Credit 2, “Construction Waste Management,” could incorporate special protections for workers engaged in the hazardous task of separating wastes. The indoor air quality credits could also be amended to reflect the importance of protecting construction workers from heat stress if the building needed to be sealed during construction (see heat stress hazard described in Section E).

An even more modest approach would be to enhance the use of LEED’s Innovation in Design credits. LEED awards between one to five Innovation in Design points for achieving significant, measurable environmental performance using a strategy not addressed by the LEED rating system.<sup>233</sup> One idea would be to develop an Innovation in Design point specifically addressing worker health and safety.<sup>234</sup> This could entail a specific activity such as hazard communication trainings for workers or a broader activity, such as establishing a worker health and safety committee or otherwise involving workers in a health and safety program.<sup>235</sup>

---

<sup>230</sup> Ibid.

<sup>231</sup> Ibid.

<sup>232</sup> Ibid.

<sup>233</sup> Ibid.

<sup>234</sup> Anonymous, industrial hygienist. Personal interview. April 5, 2010.

<sup>235</sup> Delp and Stewart, *Green Buildings, Good Jobs, Safe Jobs: Social Justice Pathways to a Sustainable Los Angeles*.

LEED also awards one Innovation in Design point for including a LEED Accredited Professional as a principal participant of the project team.<sup>236</sup> An additional credit could be offered for adding an occupational safety and health professional to the project team. That person could educate project team members about construction site safety and health, provide assistance in meeting OSHA requirements, encourage architects to design with safety in mind, and be available during on-site health and safety trainings. As an example of how effective this can be, at one company, it is required that the contractor, engineer, architect, safety professional, and plant operations and maintenance representative meet during the design phase; these series of meetings have helped reduce the company's OSHA Recordable Incident Rate of occupational injuries from 1.93 in 2004 to 0.7 in 2009.<sup>237</sup>

The challenge with all of these recommendations is that they require formal adoption by the U.S. Green Building Council, which is perceived to be less than eager to adopt additional criteria that would protect worker health.<sup>238,239,240,241</sup>

Despite resistance by the U.S. Green Building Council, there have been some preliminary discussions about how to engage the U.S. Green Building Council, and there may be some opportunities for an agency like NIOSH to play a role in assessing how worker safety could be incorporated into LEED and/or other rating systems.<sup>242,243</sup> As described in Section F.4, developing cross-training opportunities with the U.S. Green Building Council could also be helpful. And, as described in the next section, if other green building certification programs were to adopt worker health criteria, that might pave the way for LEED to evolve as well.

## **b. Other green building certification programs**

Much attention has been paid to LEED because it has the biggest market share, but many other green building ratings systems exist. These rating systems, which may not have a strong national presence, could potentially be more open to incorporating worker health and safety criteria.<sup>244</sup> Starting with these local or regional green building rating systems could be a way to drive the market and eventually nudge LEED and other national rating systems to follow.<sup>245</sup>

---

<sup>236</sup> Gillen, Check, and Branche, *Niosh Science Blog: Going Green: Safe and Healthy Jobs*(accessed).

<sup>237</sup> Anonymous, contractor. Personal interview. April 26, 2010.

<sup>238</sup> Anonymous, director of continuing education. Personal interview. February 22, 2010.

<sup>239</sup> Anonymous, professor. Personal interview. March 10, 2010.

<sup>240</sup> Anonymous, industrial hygienist. Personal interview. March 3, 2010.

<sup>241</sup> Anonymous, industrial hygienist. Personal interview. April 5, 2010.

<sup>242</sup> Anonymous, industrial hygienist. Personal interview. March 3, 2010.

<sup>243</sup> Anonymous, professor. Personal interview. March 10, 2010.

<sup>244</sup> Anonymous, industrial hygienist. Personal interview. April 5, 2010.

<sup>245</sup> Ibid.

A selection of green building certification systems are described below (also see Figure 6):

- Green Globes is administered by the Green Building Initiative (GBI). The Green Globes certification program was recently approved as the American National Standards Institute (ANSI) for commercial buildings.<sup>246,247</sup> The new standard does not directly address construction safety but does contain clean air provisions that include minimizing construction dust and diesel exhaust fumes.<sup>248</sup>
- The National Green Building Standard (NGBS), developed by the National Association of Home Builders, is a green certification program for residential homes and has been approved by the American National Standards Institute (ANSI).<sup>249</sup>
- Environments for Living (EFL), developed by Masco Home Services, Inc., is a performance-based, rather than point-based, system for certifying homes and can be paired with other rating systems like LEED.<sup>250</sup>
- The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) developed ASHRAE Standard 189.1.<sup>251</sup> This however, is not an assessment program, meaning that raters do not certify projects under the standard.<sup>252</sup>

In addition to these voluntary programs, California recently implemented the CALGreen program, which is a mandatory green building code that includes some required features as well as a voluntary system that certifies buildings as Tier 1 or Tier 2. The CALGreen program has some placeholders in certain categories that have not yet been developed.<sup>253</sup> One idea would be to provide input into any new provisions that are developed.

These and other programs would need to be evaluated to determine whether any provides an opportunity for incorporating worker health into existing criteria. Some of the specific recommendations given for the LEED program could be adapted to fit other green building rating systems. Another research area would be to evaluate green rating systems in other countries to determine if current criteria protect worker health and whether any of those approaches could be applied in the U.S. More than twenty countries have established green building certification standards including the UK (Building Research Establishment Environmental Assessment Methodology (BREEAM)), Australia (Green

---

<sup>246</sup> Anonymous, rating organization. Personal interview. April 21, 2010.

<sup>247</sup> The Green Building Initiative, *Ansi / Gbi Standard*(2010, accessed June 10 2010); available from <http://www.thegbi.org/green-globes/ansi-gbi-standard.asp>.

<sup>248</sup> Ibid.(accessed).

<sup>249</sup> National Association of Home Builders, *National Green Building Standard*(2010, accessed May 27 2010); available from <http://www.nahbgreen.org/Guidelines/ansistandard.aspx>.

<sup>250</sup> Environments for Living, *Homebuyers & Homeowners Faqs*(2010, accessed May 27 2010); available from [http://www.environmentsforliving.com/index.jsp?action=hb\\_faq#q](http://www.environmentsforliving.com/index.jsp?action=hb_faq#q).

<sup>251</sup> The American Society of Heating Refrigerating and Air-Conditioning Engineers, *The Green Standard: Standard 189.1: Standard for the Design of High-Performance, Green Buildings*(2010, accessed June 10 2010); available from <http://www.ashrae.org/publications/page/927>.

<sup>252</sup> Anonymous, rating organization. Personal interview. April 21, 2010.

<sup>253</sup> Anonymous, rating organization. Personal interview. April 21, 2010.

Star), and Japan (CASBEE).<sup>254</sup> Also, the International Code Council is working with the American Institute of Architects (AIA) and ASTM International to develop The New International Green Construction Code (IGCC).<sup>255</sup>

### **c. A stand-alone worker health and safety rating system**

Another approach is to develop an entirely new health and safety rating system that complements LEED and other green building certification systems. One such system has been developed by Sathyanarayanan Rajendran.<sup>256</sup> The proposed Sustainable Construction Safety and Health (SCSH) Rating System would award a maximum of 100 credits, including some required elements.<sup>257</sup> Projects would need to score at least 54 credits to be certified, and could attain one of four tiers of certification.<sup>258</sup> Credits would be awarded in these categories:

- Project Team Selection (e.g., project team is made up of contractors, subcontractors, and designers that are selected based on a set of specific criteria)
- Safety and Health in Contracts (e.g., the construction contract includes safety and health requirements; the designer specifies the use of less hazardous materials)
- Safety and Health Professionals (e.g., competent persons are assigned for all high hazard tasks; the owner, contractor, and subcontractor designate key safety professionals)
- Safety Commitment (e.g., contractors and subcontractors sign a safety mission statement; the owner participates in various safety activities)
- Safety Planning (e.g., worker safety is considered during the planning phase; the contractor and subcontractor provide site specific safety plans; job hazard analyses are prepared for all tasks; all traffic and the flow of materials are controlled on and off site; workers are provided personal protective equipment)
- Training and Education (e.g., designers, workers, field supervisors are trained in construction worker safety; foremen conduct toolbox meetings regarding safe work practices and procedures)
- Safety Resources (e.g., a task-based hazard exposure database is created and made available to all project personnel)
- Drug and Alcohol Program (e.g., all workers are tested for drugs and alcohol)
- Accident Investigation and Reporting (e.g., accidents and near misses are investigated and recorded)
- Employee Involvement (e.g., workers are empowered to stop hazardous work)
- Safety Inspection (e.g., designated persons conduct safety inspections on a regular basis; all safety violations are corrected immediately)

---

<sup>254</sup> United Nations Environment Programme, *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World*.

<sup>255</sup> International Code Council, *International Green Construction Code*(2010, accessed June 14 2010); available from <http://www.iccsafe.org/cs/igcc/pages/default.aspx>.

<sup>256</sup> Rajendran, "Sustainable Construction Safety and Health Rating System".

<sup>257</sup> Ibid.

<sup>258</sup> Ibid.

- Safety Accountability and Performance Measurement (e.g., roles, responsibilities, and accountability are clearly defined; safety performance of project supervisor is evaluated)
- Industrial Hygiene Practices (e.g., engineering controls are prioritized; hearing and respiratory protection are used; stretching exercises are performed each day)<sup>259</sup>

The SCSH Rating System represents the most comprehensive rating system for worker health that has been proposed, and has been validated based on 25 construction projects.<sup>260,261</sup> One of the key results is that construction safety must be the responsibility not just of the contractor but of all parties including the owner, designer, contractor, and subcontractors.<sup>262</sup>

Possible improvements to the rating system could include awarding points for: developing an effective safety plan that mirrors California's Injury and Illness Prevention Plan and/or other similar state plans; having a labor-management health and safety committee; developing a system for reporting hazards anonymously; and holding bilingual safety trainings.

One of the challenges of the SCSH Rating System is that great resources are needed to support the infrastructure required to administer it. The certification program would likely need to be administered by a nonprofit agency similar to the U.S. Green Building Council. A team of certified raters, as well as a certification program to go with it, would also be needed to evaluate projects. Marketing the program would also be essential.

A similar concept that is already being implemented is a pre-qualification system that developers can use to evaluate the safety performance of contractors. Harvard University, one of the biggest developers in the Boston area, developed ConstructSecure, The Contractor Safety Assessment Program, to screen contractors and subcontractors based on criteria including: OSHA citation history, loss history, data on days away from work, data on near misses, and the existence of management systems and safety programs.<sup>263,264</sup> (The complete list of criteria and assignment of points are not available to the public.) Contractors that meet the qualification criteria are certified; those that receive high scores are given Platinum or Gold designation and are listed on the ConstructSecure website.<sup>265</sup> By screening out poor performers, injury and illness rates decreased, in one year, from 6 to 1.8 incidents.<sup>266</sup> Five hundred contractors are currently

---

<sup>259</sup> Ibid.

<sup>260</sup> Ibid.

<sup>261</sup> Sathyanarayanan Rajendran and John Gambatese, "Development and Initial Validation of Sustainable Construction Safety and Health Rating System," *Journal of Construction Engineering and Management* 135, no. 10 (2009).

<sup>262</sup> Ibid.

<sup>263</sup> *Constructsecure, the Contractor Safety Assessment Program*, (accessed March 3 2010); available from <https://www.constructseer.com/home.html>.

<sup>264</sup> Anonymous. Personal interview. March 3, 2010 and May 24, 2010.

<sup>265</sup> *Constructsecure, the Contractor Safety Assessment Program*, (accessed).

<sup>266</sup> Anonymous. Personal interview. March 3, 2010.

enrolled in the program and the program is now being used by other companies, as well as contractors that need to evaluate the safety performance of subcontractors.<sup>267</sup> In addition to certifying contractors and subcontractors, this program provides webinars and trainings to certified contractors as well as to poor performers that score too low to participate in the program.<sup>268</sup>

This is a useful tool for owners and developers, and more sophisticated than a scorecard system, described below, that does not come with independent certification. Prequalification systems like this, and particularly ones that are transparent in terms of the criteria and weighting of criteria, are an important step to enable owners and large developers to hire contractors who will perform the job safely and to nudge contractors to adopt effective health and safety programs.

#### **d. Scorecard**

Another approach is to sidestep a formal certification process and develop a list of criteria that owners or developers could use to quickly evaluate the safety performance of contractors. One particular scorecard system has been developed and validated as being an effective predictor of safety performance.<sup>269</sup> In this system, some of the key criteria that influence construction safety include: the project characteristics, selection of safe contractors, contractual safety requirements, and the owner's proactive involvement in safety management.<sup>270</sup> The scorecard appears on the next page (p. 59).

---

<sup>267</sup> *Constructsecure, the Contractor Safety Assessment Program*, (accessed).

<sup>268</sup> Anonymous. Personal interview. March 3, 2010.

<sup>269</sup> Huang and Hinze.

<sup>270</sup> Xinyu Huang and Jimmie Hinze, "Owner's Role in Construction Safety: Guidance Model," *Journal of Construction Engineering and Management* 132, no. 2 (2006).

Figure 7: Construction Safety Scorecard <sup>271</sup>

Project Context, Contractor Selection, Contractual Safety Requirements and Owner Involvement in Project Safety		Answer	
<b>Project context:</b>			
(1) Does the project work one shift?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(2) Does the project work five days a week or less?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
<b>Selection of contractor</b>			
(3) Is the TRIR requirement for the contractor selection less than 2.0?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(4) Are the qualifications of the project team reviewed?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(5) Are the qualifications of the safety staff reviewed?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(6) Does the evaluation of each contractor's safety performance make a difference in awarding the contract?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
<b>Contractual safety requirements</b>			
(7) Does the project use a design-build contract?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(8) Does the contract require the contractor to place at least one full-time safety representative on the project site?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(9) Does the contract require the contractor to submit all safety personnel résumés for the owner's approval?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(10) Does the contract require the contractor to prepare a site-specific safety plan?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(11) Does the contract require the contractor to submit a safety policy signed by its CEO?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(12) Does the contract require the contractor to provide a minimum specified amount of training to the construction workers?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
<b>Contractor Safety Program Requirements</b>			
Which of the following are required to be included in the contractor's safety program?			
(13) Contractor must prepare a plan for site emergencies	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(14) Contractor must conduct pre-task safety planning on the project site	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(15) Contractor must implement a substance abuse testing program	<input type="checkbox"/> Y	<input type="checkbox"/> N	
<b>Owner's involvement in project safety management</b>			
(16) Does the owner's safety representative investigate near misses?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(17) Are injury statistics on the projects maintained separately on each contractor?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(18) Are all project injuries included in the owner's overall measure of safety performance?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(19) The owner actively participates (gives presentations) during worker safety orientation?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(20) Comprehension of safety training is evaluated through testing?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
Which of the following activities are performed by the owner's site safety representative?			
(21) Enforcing safety rules and regulations	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(22) Monitoring of the implementation of pre-task planning	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(23) Participating in safety recognition programs	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(24) Participating in safety and/or tool box meetings	<input type="checkbox"/> Y	<input type="checkbox"/> N	
(25) Does the owner set zero injuries as its safety expectation before the commencement of site work?	<input type="checkbox"/> Y	<input type="checkbox"/> N	
<b>Total Count of Yes Responses</b>			
Multiply the Yes Count by 4		(X 4)	%

**What the score means:**

High score implies strong owner involvement  
 Low score implies weak owner involvement

Note: TRIR is the OSHA Total Recordable Incidence Rate.

<sup>271</sup> Ibid.

Under this scorecard system, a high score means that owners are more involved in project safety, the implication being that strong owner involvement translates into greater construction safety. What is advantageous about this scorecard is that it encourages the owner to think about his or her role in construction safety as opposed to placing all of the responsibility on the contractor. To be useful, the above scorecard would need to be adapted and written from the perspective of the owner evaluating a prospective contractor and his/her relationship with that contractor. Although this scorecard is not nearly as sophisticated as the stand-alone Sustainable Construction Safety and Health system summarized above and would not involve third party certification, it is a user-friendly tool that owners and developers could use to evaluate contractor safety and owner involvement. One could also imagine developing a tool similar to this one that would evaluate the safety performance of designers.

To give the scorecard some teeth, one idea is to develop model contracts with language that protects the health and safety of construction workers. The Rhode Island Committee on Occupational Safety and Health has developed an innovative project to encourage institutions, developers, designers, and professional organizations to adopt a “Green During Construction” pledge so that in selecting a contractor and in designing the specifications for a project, special attention is paid to air quality issues.<sup>272</sup> The model contract contains language specifying the hazards that must be controlled: diesel exhaust, gasoline exhaust, dust, and crystalline silica dust.<sup>273</sup> The pledge has been adopted by Brown University, the Rhode Island Public Transit Agency, and others.<sup>274</sup> Though this particular model contract is limited to specific hazards, this language could be broadened to encompass other construction hazards, though a larger package of commitments might be more difficult to sell to owners, developers, and designers. If a scorecard were being used in conjunction with model contract language, contractors would first be pre-screened using the scorecard system and then would be held to certain safety practices under the contract.

As already noted, rating systems, especially voluntary ones, are part of the solution and not the whole picture. There must also be strong OSHA enforcement as well as a sharing of responsibility among owners, contractors, and designers for worker safety.

---

<sup>272</sup> Rhode Island Committee on Occupational Safety and Health, *Green During Construction* (accessed June 8 2010); available from <http://coshnetwork6.mayfirst.org/node/133>.

<sup>273</sup> *Ibid.* (accessed).

<sup>274</sup> *Ibid.* (accessed).

## 4. Promote construction safety training

Construction safety training needs to reach not just construction workers but also contractors, owners, and designers. There needs to be more resources allocated to developing training in this area. The federal Green Jobs Act, Washington State's Climate Action and Green Jobs Act, the Massachusetts Green Jobs Act, the California Green Jobs Act, and other laws have launched efforts to evaluate training needs and, in some cases, issued grants to support training.<sup>275</sup> These efforts should be assessed to determine whether existing programs are meeting the need for training and particular skills. Federal, state, and local resources are necessary to properly prepare construction workers for green jobs, and to assist organizations in developing entirely new capacity to reach out to contractors, owners, and designers.

We need to act quickly to train workers in emerging green jobs.<sup>276</sup> Any training course that teaches green jobs skills should also teach workers how to execute those skills safely. Courses should educate workers about the hierarchy of workplace controls and the importance of engineering control measures so that workers, though they cannot implement them on their own, are aware of the need to design out safety hazards. Also, as described in Section D, certain occupations within the green construction industry are anticipated to be high-growth (such as heating, air conditioning, and refrigeration mechanics and installers; insulation workers; helpers, carpenters; helpers, electricians; pipelayers, plumbers, pipefitters, and steamfitters). Health and safety trainings should pay special attention to hazards in those particular occupations or could be developed specifically for those occupations. For example, referencing the list of hazards in Section E, insulation installers need to be trained to avoid exposure to isocyanate.

Another recommendation is to build worker awareness about how his or her job fits into the green building movement and what makes it a green job. This helps the worker think more critically about what products and techniques should be considered "green" and provides the foundation for the worker to advocate for sound environmental practices. Being educated about what "green" should mean and how loosely defined it can be will prevent construction workers from assuming that a green building is automatically safe and healthy.<sup>277</sup>

There are already curricula and tools out there for building worker awareness about green building and how it impacts the environment. For example, the University of Washington, Department of Environmental & Occupational Health Sciences, recently rolled out a new green building training that provides important background information on how green building contributes to sustainability. Another useful tool is a YouTube video developed by the State Building & Construction Trades Council of California that shows how each of the different trades contributes to the energy saving, water saving,

---

<sup>275</sup> Delight Balducci and others, *Green Jobs Position Paper: Green Jobs in New York: Where the (Green) Economy Meets the (Green) Environment*(accessed May 17 2010).

<sup>276</sup> Gillen, Check, and Branche, *Niosh Science Blog: Going Green: Safe and Healthy Jobs*(accessed).

<sup>277</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

recycling, and other goals of green construction.<sup>278</sup> Another film, “The Greening of Southie,” chronicles the construction of a LEED-certified building in South Boston and addresses challenges such as having to tear up 72 bamboo floors and order new flooring all the way from China because a low-VOC adhesive failed.<sup>279</sup> These videos and other tools like it could be used in green jobs training classes to help contextualize the often very specific jobs that workers are tasked with and to help workers think through the benefits and also potential drawbacks of green building products and practices.

The critical piece, of course, is teaching workers about hazards they may encounter on the job. The workplace hazards associated with green jobs summarized in section E of this report are a good starting point for developing case studies and concrete examples that can be used in trainings for workers to practice identifying hazards, analyzing the underlying causes of injury, and brainstorming hazard controls. Some of this has already been done. As one example, the Labor Occupational Health Program at the University of California at Berkeley has developed a safe green jobs training that uses case studies, including a case study of the death of an electrical worker installing a solar panel, as a way for workers to think about the underlying causes of injury and what could have been done to prevent these accidents (see case studies in Appendix A).<sup>280</sup>

Another recommendation is to work with community organizations, unions, and community and technical colleges to develop strong workplace health and safety modules as part of their existing green jobs training programs. Many training programs already exist and are too numerous to list here. Some programs may need significant technical assistance from an industrial hygienist or other safety professional; other programs may only need short health and safety modules that are easy to insert into existing curricula.

We also need to reach non-union and immigrant construction workers who, as discussed above in Section E, are more likely to be injured on the job. This includes day laborers who may be tasked with smaller scale green projects like installing insulation. Trainings and materials for these populations need to be low-literacy and may need to be translated into different languages.

The existing OSHA 10-hour and 30-hour construction trainings, though they vary widely depending on the provider, tend to have gaps in terms of addressing green building skills and technologies. For example, a generic OSHA 10-hour course that cautions workers to shut off power before conducting any work by pulling the main breaker is insufficient advice if there is a solar electrical system in place that is still energized. Existing courses may not address how to work safely with these new alternative energy systems not just in terms of workers installing the systems but the workers who come later to work on other components of the building. A few other examples of gaps in OSHA 10-hour and 30-

---

<sup>278</sup> State Building & Construction Trades Council of California, *Building Green Skills in California* (2010, accessed); available from <http://www.youtube.com/watch?v=sh4SWBbr95g&feature=related>.

<sup>279</sup> Ian Cheney, "The Greening of Southie," (2008).

<sup>280</sup> Labor Occupational Health Program at the University of California at Berkeley, "Safe Green Construction Curriculum."

hour courses include what respiratory protections are needed when working with fiber cement panels and how to minimize the ergonomic risk associated with carrying unusually large and unwieldy window panes used in atriums.<sup>281</sup> A few nonprofit organizations that specialize in occupation safety and health are adapting their OSHA 10-hour courses with these new green construction hazards in mind.<sup>282,283</sup>

One recommendation is for OSHA to re-evaluate the 10-hour and 30-hour courses and add additional criteria that address green construction and green building products or even add a special course in green construction (e.g., “OSHA Green Card”). Also, it appears that the topic of hazard communication is not actually required as part of the OSHA 10-hour course; instead, hazard communication is provided as an *example* of what could be taught in the “Health Hazards in Construction” module. To promote hazard communication in the face of new green products with uncertain health effects, OSHA could specify in its “Health Hazards in Construction” requirement that hazard communication is a mandatory subtopic.<sup>284</sup> OSHA could also include green construction topics as electives. OSHA could provide funding for trainers to develop green construction safety modules that could then be widely distributed to authorized trainers to incorporate into their 10-hour or 30-hour courses. These green modules could also be added to the OSHA website, which already offers free Powerpoint presentations for specific types of hazards. As OSHA 10-hour and 30-hour courses tend to be lecture-oriented,<sup>285</sup> these new modules could use case studies, small group activities, and other participatory teaching methods to deepen participants’ learning. OSHA could also require that courses emphasize the hierarchy of controls and construction safety by design.<sup>286</sup>

Contractors need construction safety training as well. As employers, they control the work and how it is performed, and thus need to be familiar with the hierarchy of controls. By understanding the importance of engineering controls, contractors could make specific recommendations to designers so that fewer work practices need to be put in place and there is less dependence on personal protective equipment. Additionally, in some states, supervisors are required to take the OSHA 10-hour course depending on their specific job tasks.<sup>287</sup> States that do not already do so could also consider mandating the OSHA 10-hour or 30-hour course for supervisors. Trainings for contractors would also need to emphasize the importance of frequent trainings for employees to keep them up-to-date on how to work safely with new technologies and products.

---

<sup>281</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

<sup>282</sup> Ibid.

<sup>283</sup> Anonymous, occupational safety and health organization. Personal interview. June 14, 2010.

<sup>284</sup> U.S. Occupational Safety and Health Administration, *Outreach Training Program Guidelines, Construction Industry Safety and Health* (February 2009, accessed); available from [http://www.osha.gov/dte/outreach/construction\\_generalindustry/construction.html](http://www.osha.gov/dte/outreach/construction_generalindustry/construction.html).

<sup>285</sup> Anonymous, occupational health and safety trainer. Personal interview. May 24, 2010.

<sup>286</sup> "Policy Recommendations from the National Worker Safety and Health Summit," in *National Worker Safety and Health Summit, convened by the Protecting Workers Alliance* (Philadelphia, PA: 2010).

<sup>287</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

Though formal and comprehensive construction safety training may not be necessary for most owners, they do need to be aware of job hazards and proactively bring together designers and contractors at the early design stage to tackle safety issues. To reach individual owners retrofitting their own home, we need to share workers' stories in the mainstream media and conduct targeted campaigns to educate those who are receiving subsidies to weatherize their house. For example, one national program called the Green and Healthy Homes Initiative, integrates low-income weatherization programs with lead poisoning prevention and asthma management.<sup>288</sup> Though this program does not currently address worker health, it presents an innovative approach to using weatherization programs to intervene on health issues. For owners that are repeat players, including institutions and major developers, construction safety training may be appropriate. Such a training would focus on the hierarchy of controls and emphasize the role that the owner plays in creating a safe culture and directing that designers address construction safety from the start.

As discussed in Section F.2 of this report, designers also need to be informed about the choices that they can make to enhance construction worker safety. Until designers are on board, it will be a challenge to put in place proper engineering controls that have the most potential to reduce injuries and illnesses. This is a group that can be difficult to reach; for example, one health and safety group has tried to reach out to designers but has not had a lot of success.<sup>289</sup> Another health and safety group has had some discussions with designers but says, "It's been a tough road. It's about jobs, and health and safety is the last thing people want to talk about."<sup>290</sup> Some companies have had great success in training their own engineers in construction safety and safety in design,<sup>291</sup> but more widespread change is needed. Part of the answer lies with changing curricula at the university level. In construction and civil engineering programs, it has been suggested that construction safety could be taught more effectively and that the use of internships and other learning environments could be used to supplement classroom learning.<sup>292</sup> A more modest approach would be to require architects and engineers to take, at a minimum, the OSHA 10-hour course.<sup>293</sup>

There may also be important cross-training opportunities. In the same way that occupational safety and health professionals and trainers are now learning about climate change and how green jobs can combat climate change, the occupational health community needs to reach out to environmental groups and provide them with information about green job hazards. Just as the occupational health community has helped build health and safety capacity in unions and community organizations, the same needs to happen in the environmental and green building community. A training course

---

<sup>288</sup> Anonymous, advocacy organization. Personal interview. June 21, 2010.

<sup>289</sup> Anonymous, occupational safety and health organization. Personal interview. June 9, 2010.

<sup>290</sup> Anonymous, occupational safety and health organization. Personal interview. June 14, 2010.

<sup>291</sup> Tom Zarges and Brad Giles, "Prevention through Design (PtD)," *Journal of Safety Research* 39 (2008).

<sup>292</sup> Gambatese, "Safety Emphasis in University Engineering and Construction Programs."

<sup>293</sup> Michael T. Toole, "Rethinking Designers' Roles in Construction Safety," in *Designing for Safety and Health in Construction*, ed. Steven Hecker, John Gambatese, and Marc Weinstein (Portland, Oregon: 2003).

on green construction job hazards tailored for the environmental community could be brought to members of the Blue-Green Alliance, the U.S. Green Building Council, and other groups.

## **G. Conclusion**

---

Green buildings, as they are currently designed and built, are likely to cause just as many construction worker injuries and illnesses as traditional buildings. Unless we fundamentally change the way that we think about what it means to be green, we will soon be faced with a steadily growing stock of green buildings in which solar panel installers have fallen off the roofs and died, electricians have been burned while handling solar hot water collectors, laborers separating materials for recycling have been punctured by nails, insulation installers have been over-exposed to isocyanate, and technicians have been electrocuted while working on wind turbines. This is not the sustainable future that the green building community is aiming for.

Changing the perception of what is green is the first step to institutionalizing worker health protections as a part of policies and practices related to green jobs. To do this, some in the occupational health community will need to engage advocates, researchers, and policy analysts at an abstract level to broaden the still-evolving definition of green jobs to include worker health and other key components of sustainability. Others in the occupational health community will need to widely share the concrete, real stories about green construction workers who have become injured or even died on the job. We need to create in the public's mind an association between green jobs and worker health. There is no industry in which this is more important than in construction, which accounts for almost one-quarter of all worker fatalities in the U.S.

Adding increased complexity to an already complex debate will be difficult, but this is the obligation we have to workers. Unless there is increased awareness among the public and among key decision-makers about the need to promote green construction safety, we will always be stymied in our efforts to implement the many changes needed in the construction industry: designing for construction safety in a way that addresses the underlying causes of injury and illness; integrating worker health into green building rating systems; and providing sufficient training for owners, designers, contractors, and workers. As the country slowly moves to embrace an environmental ethos, we have an opportunity to infuse that ethos with an accompanying respect and just treatment of the workers -- members of the current generation -- who are each doing their small part to protect the environment for future generations.

# **APPENDIX A: Case Studies**

**The following five case studies were developed by the Labor Occupational Health Program (LOHP) at the University of California at Berkeley. They are meant to be used as a teaching tool in green construction safety courses. Each case study is made up of a handout that includes a description of a true incident that occurred on a construction site, followed by questions for the class. Each case study also has an answer sheet for the instructor that outlines suggested answers and ideas.**

**All or portions of these materials may be reproduced without permission for educational purposes. Please credit LOHP.**

## **Case Study: Solar Panel Installer Dies from Fall**



On the day of the accident, the victim and his co-worker were carrying and installing electrical solar panels on the roof of a warehouse. The roof contained skylights, which were marked by the manufacturer as “tested in accordance” with OSHA fall protection standards. The general contractor had reviewed the job safety requirements including fall protection plans. Based on the information that the skylights had been tested in accordance with OSHA standards, no other fall protection measures were implemented at the job site. There are currently no uniform test criteria to determine material strength of skylights to withstand worker impact.

The solar panels were boxed and placed on the roof by a crane. Each panel was approximately two feet wide by four feet long, and weighed 24 pounds. The victim and co-worker were carrying two panels at a time. As they approached a skylight, they had to maneuver around it with only 18 inches of clearance. The victim turned and walked backwards, tripping on the raised edge of the skylight. He landed on the skylight in a sitting position and then, without warning, the plastic dome glazing broke. As the victim started to fall, a co-worker reached out and tried to grab his foot, but was unable to reach him in time. The victim fell approximately 40 feet to the warehouse floor below. Numerous workers with radios immediately called the office to report the incident and those with cell phones immediately called 911. The paramedics and fire department responded within minutes and pronounced the victim dead at the scene.

**What went wrong? What caused this fatality?**

**How could this accident have been prevented?**

## Answers to Case Study: Solar Panel Installer Dies from Fall

### What went wrong? What caused this fatality?

- The employer assumed that fall protection was unnecessary.
- No fall protection methods were used.

### How could this accident have been prevented?

Develop, implement, and enforce a fall protection program to prevent falls through skylights. There are currently no uniform test criteria to determine material strength of skylights to withstand worker impact. Such test criteria would include the degradation of plastic or plastic-containing materials after several years of sun exposure and the ability to withstand a point impact. One organization, ASTM International, is currently developing such testing guidelines. **At this time, employers should not assume that manufacturer testing ensures that a particular skylight can sustain the impact of a worker. In order to prevent falls through skylights, employers should implement and maintain a fall protection program that includes:**

- Skylight screens capable of safely supporting the greater of 400 pounds or twice the weight of the employees plus his equipment and materials, or
- Guardrails around the skylight at least 45 inches in height with a top rail and mid rail which should be half way between the bottom surface and top rail. The rails should be able to withstand a live load of 20 pounds per square foot.
- If these two methods are not feasible, then the use of personal fall protection should be utilized. A personal fall protection system consists of a body harness, lanyard and anchor points. Had any of these fall protection methods been used at this job site, the victim would not have fallen through the skylight to the ground below.

**(California FACE Report #09CA003)**

## **Case Study: Wind Turbine Tower Collapses**



In 2007, a man died at a wind farm under construction in Oregon in what is believed to be the first death of a wind power worker from a tower collapse in the United States. Three wind technicians were performing maintenance on a wind turbine tower. The technicians working on the turbine each had less than two months' experience and there was no supervisor on site.

After applying a service brake to stop the blades from moving, one of the workers entered the hub of the turbine. He then positioned all three blades to the maximum wind resistance position and closed all three energy isolation devices on the blades. The devices are designed to control the mechanism that directs the blade pitch so that workers don't get injured while they are working in the hub.

Before leaving the confined space, the worker did not return the energy isolation devices to the operational position. As a result, when he released the service brake, an overspeed condition caused one of the blades to strike the tower. The tower then buckled and collapsed, crushing and killing the worker. The second worker, who was on his way down a ladder inside the turbine, was injured. The third worker outside the tower was unharmed.

**What went wrong? What caused this fatality?**

**How could this accident have been prevented?**

## **Answers to Case Study: Wind Turbine Tower Collapses**

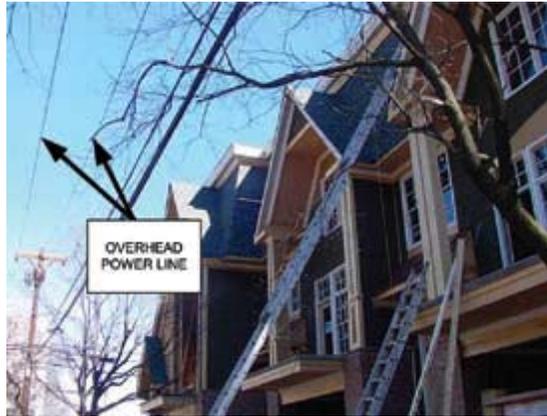
### **What went wrong? What caused this fatality?**

- The workers were not properly instructed and supervised in the safe operation of the machinery, tools, or equipment they were authorized to use. The workers were unaware of the potential for catastrophic turbine failure if the blades were not properly restored to their operational position.
- The company's procedures for controlling potentially hazardous energy during service or maintenance activities did not fully comply with OSHA regulations. OSHA requirements included developing, documenting, and using detailed procedures and applying lockout or tagout devices to secure hazardous energy in the "safe" or "off" position during service or maintenance. Several energy isolation devices in the towers (valves and lock pins) were not designed to hold a lockout device, and energy control procedures in place at the time of the accident did not include the application and removal of tagout devices.
- The workers who were required to enter the hub (a permit-required confined space) or act as attendants to employees entering the hub had not been trained in emergency rescue procedures.

### **How could this accident have been prevented?**

- Train workers on the safe operation of wind turbine machinery.
- The company's procedures should comply with OSHA regulations. Lockout tagout procedures should be developed and applied. Wind turbine equipment should be designed for lockout tagout devices.
- The wind turbine system should be designed to prevent any operator from restarting the turbine while the blades are locked in a hazardous position.
- Train all workers who are required to enter the hub about confined spaces and emergency rescue procedures.

## Case Study: Weatherization Worker Gets Electrocuted



On a hot, humid day, a two-man weatherization crew arrived at a two-story home to blow cellulose insulation into the attic and then install roof vents. They were aware of overhead power lines in front of the home and planned the job with that danger in mind. Since the home is attached to other structures on each side, they could access the home only from the front or rear. The two men planned to enter the attic by cutting a hole in the roof. To reach the roof, the men needed to use an extension ladder. The victim, who wore sneakers, stood on the front sidewalk facing the center of the house and steadied the aluminum ladder by holding it upright with both of his hands at shoulder height and his feet on either side of the ladder. His partner pulled the rope to fully extend the ladder to 32 feet. He stood with his back to the house, facing the victim. He was looking up as he pulled the rope, heard the victim call his name, and then saw him shaking. He pulled the rope to release the victim from the ladder and the electrical contact. According to the medical examiner, death was caused by electrocution.

**What went wrong? What caused this fatality?**

**How could this accident have been prevented?**

# **Answers to Case Study: Weatherization Worker Gets Electrocuted**

## **What went wrong? What caused this fatality?**

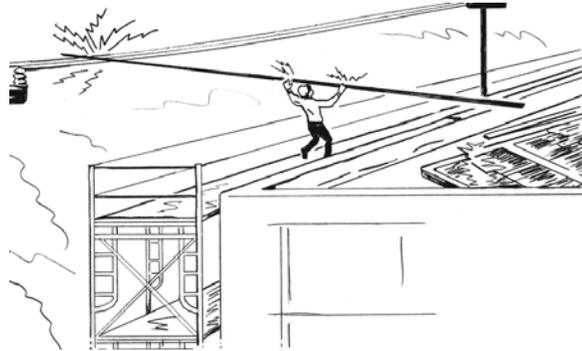
- The workers were working too close to a power line.
- They were using a metal ladder.
- The employer did not inform the subcontractor or workers of the hazard assessment plan.
- The employer did not ask the power company to de-energize the lines or request insulating sleeves.

## **How could this accident have been prevented?**

- Because of the nature of the homes and structures that the workers must weatherize, it is necessary that each site and situation be evaluated for potential hazards. The general contractor should identify safety hazards before the work takes place and address how to reduce exposure to the hazards in his or her written instructions to the subcontractor.
- The power company representative who inspects the house to be weatherized should look for electrical and other potential hazards and inform the subcontractor about them.
- Once it has been determined that there is a potential for equipment to come into contact with energized power lines, the utility company should be asked to de-energize the lines, or cover the lines with insulating sleeves.
- The employer must provide safety training that informs employees about potential hazards to which they may be exposed, particularly when working near overhead power lines.
- According to OSHA, portable metal ladders may not be used in areas in which they may make contact with electrical conductors. Fiberglass and dry wood ladders are better nonconductors.
- Make sure workers, their tools and building materials are a safe distance (at least 10 feet for most work) from high voltage power lines.

**(New Jersey FACE Report #90NJ013 (formerly NJ9009). Go to the following website for more information: <http://www.nj.gov/health/eoh/survweb/face.htm>)**

## Case Study: Solar Technician Fatality



A solar technician was installing a solar panel system on a building along with two co-workers. Their supervisor had instructed them to strap a solar hot water tank to the roof using a 20-foot aluminum bracket. The crew tied rope around the bracket and climbed an existing scaffold at the rear of the building. The technician was positioned at the top of the scaffold and was pulling the rope to raise the bracket. As he lifted the bracket to the top of the building, he turned it to a horizontal position. In the process, the bracket came in contact with high voltage electrical lines that were 10 feet away from the scaffold. He was electrocuted and fell 35 feet to his death.

The technician had been in the United States for five years. For the past two years, he had worked off and on as a solar technician for a solar energy contractor. Most routine job and safety instructions between company supervisors and the technician were in Spanish.

The contractor had a safety program with written safety policies and instructions on how to work safely for most tasks, including lifting materials. Only some of these instructions were written in Spanish. There was also a solar training program that included either classroom instruction from solar equipment manufacturer representatives or on-the-job training from experienced solar technicians. The solar training covered some electrical hazards, but did not include hazard recognition and safe work procedures around high voltage electrical lines.

**What went wrong?**

**How could this accident have been prevented?**

# **Answers to Case Study: Solar Technician Fatality**

## **What went wrong? What caused this fatality?**

- The contractor should have conducted a job site analysis before the work began to identify potential safety problems.
- The technician wasn't informed of potential worksite hazards, like working near overhead power lines.
- All safety information was not provided in a language that the technician could understand.

## **How could this accident have been prevented?**

Solar energy contractors should:

- Conduct a daily job hazard analysis of the work area, including any electrical hazards from high voltage power lines.
- Establish and maintain safety programs that include electrical hazard recognition, including high voltage power lines.
- Develop and implement strict safety procedures when working around high voltage power lines.
- Contact the local electric power company and have the power turned off when working within a certain distance of high voltage power lines or ask that insulating sleeves be used over the energized power lines.
- Make sure workers, their tools and building materials are a safe distance (at least 10 feet for most work) from high voltage power lines.
- Translate all safety materials to Spanish and ensure that any new workers receive training on hazards, including how to work safely around high voltage power lines.

**(California FACE Report #08CA006)**

## **Case Study: Construction Laborer Run Over by Front-end Loader**



A 19-year-old male construction laborer, performing the duties of a grade checker and directing traffic at a construction site, was inadvertently backed over by a front-end loader and killed. The victim had entered the moving equipment's immediate work area. The equipment operator lost sight of him. The front-end loader's backup alarm was not working at the time of the incident. The victim had never received formal comprehensive safety training. The company did not have a written code of safe practices that covered the hazards of working in close proximity to moving heavy equipment.

**What went wrong? What caused this fatality?**

**How could this accident have been prevented?**

# **Answers to Case Study: Construction Laborer Run Over by Front-end Loader**

## **What went wrong? What caused this fatality?**

- The equipment operator lost sight of the checker.
- The front-end loader's backup alarm was not working.
- The checker had never received formal comprehensive safety training.
- The company did not have a written code of safe practices that covered working close to moving heavy equipment.

## **How could this accident have been prevented?**

In order to prevent future occurrences, as part of the Injury and Illness Prevention Program (IIPP), employers should:

- Ensure that employees remain out of the immediate area where heavy equipment is operating.
- Ensure that when visual contact is lost with workers on foot, the equipment operator stops the heavy equipment and does not resume until visual contact is re-established.
- Ensure that the equipment being used has a working back-up alarm.
- Ensure that Injury and Illness Prevention Programs include a written code of safe practices on all hazards associated with the work being performed.
- Ensure that employees are adequately trained.

**(California FACE Report #02CA010)**

# APPENDIX B:

## Resources

### Health and Safety in Green Construction

**Accident Investigation Summaries.** This database by the U.S. Occupational Safety and Health Administration provides summaries of work-related accidents and fatalities. This is an important source for creating case studies. Go to:

<http://www.osha.gov/pls/imis/accidentsearch.html>

**California Building Trades Council.** This site has factsheets, guides, and checklists for the Focus Four construction hazards. Under “Building Trades Issues”, click on the link to “health and safety”:

<http://www.sbctc.org>

**Construction Solutions Database.** CPWR - The Center for Construction Research and Training maintains a database of information on health hazards and practical control measures. Go to:

<http://www.cpwrc constructionsolutions.org>

**Design for Construction Safety.** This website, which is maintained by Mike Toole at Bucknell University in conjunction with the OSHA Alliance Program Construction Roundtable workgroup on designing for construction safety and the NIOSH NORA Construction Sector Council Construction Hazards Prevention through Design workgroup, offers design ideas to improve worker safety. Go to:

<http://www.designforconstructionsafety.org>

**The electronic Library of Construction Occupational Safety and Health (eLCOSH).** This repository of construction safety and health materials, including videos, handouts, manuals, toolbox talks and research reports, offers users a wealth of information to aid in improving jobsite working conditions. Go to:

[www.elcosh.org](http://www.elcosh.org)

**The Green Collar Economy.** This book by Van Jones includes a very extensive Resource List of organizations, coalitions, and agencies involved in the larger green jobs movement:

Jones, Van. *The Green Collar Economy: How One Solution Can Fix Our Two Biggest Problems*. New York: HarperCollins, 2008.

**Labor Occupational Health Program (LOHP) at the University of California at Berkeley.** This website offers publications and other materials on a variety of workplace hazards including a Tailgate Training for California Construction Workers, which is available in both English and Spanish. Go to:

<http://www.lohp.org>

**Labor Occupational Safety and Health (UCLA-LOSH) at the University of California at Los Angeles.** This website has factsheets on workplace health and safety topics and links to its publications on good, green, safe jobs. Go to:

<http://losh.ucla.edu/>

**The Laborers' Health and Safety Fund of North America.** This website has tips on controlling some of the major hazards in construction. Go to:

<http://www.lhsfna.org/index.cfm>

**Multilingual Health and Safety Resources: A Guide to Worker Training Materials on the Web.** The California Commission on Health and Safety and Worker's Compensation provides a collection of links to training materials for construction workers and other workers. These materials are available online in various languages. Go to:

<http://www.dir.ca.gov/chswc/MultilingualGuide/MultilingualGuideMain.html>

**National Council for Occupational Safety and Health (National COSH).** The National COSH is a network of 21 local and statewide coalitions made up of unions, health and technical professionals, and individuals concerned about workers' rights to safety and health. Click on "Campaigns" to link to a page on its Green Jobs - Safe Jobs campaign. Click on "Local COSH Groups" to link to state and local COSH groups that are also working on green jobs.

<http://www.coshnetwork.org/>

**National Institute for Occupational Safety and Health (NIOSH).** NIOSH maintains a website that addresses green jobs and health and safety, and describes its initiative on Prevention through Design. The website also links to health and safety information for the construction industry and to the National Occupational Research Agenda (NORA). Go to:

<http://www.cdc.gov/niosh/topics/PtD/greenjobs.html>

**U.S. Occupational Safety and Health Administration (OSHA).** OSHA offers eTools, which are stand-alone, interactive web-based training tools on occupational safety and health topics. Many of the topics pertain to construction. Go to:

<http://www.osha.gov/dts/osta/oshasoft/index.html>

# BIBLIOGRAPHY

- Constructsecure, the Contractor Safety Assessment Program* accessed March 3 2010; Available from <https://www.constructseer.com/home.html>.
- Nansulate Homeprotect Clear Coat* accessed May 3 2010; Available from [http://www.nansulate.com/nansulate\\_homeprotect\\_clearcoat.htm](http://www.nansulate.com/nansulate_homeprotect_clearcoat.htm).
- "Nanotech & Green Building." *Progressive Investor*, no. 49 (2007).
- "The Construction Design and Management Regulations, Part 2, Section 11." 2007.
- "Opu Issued in Fatal Solar Install." *Cal-OSHA Reporter* 37, no. 15 (2010): 9723.
- "Policy Recommendations from the National Worker Safety and Health Summit." In *National Worker Safety and Health Summit, convened by the Protecting Workers Alliance*. Philadelphia, PA, 2010.
- Achutan, Chandran, and Rick Driscoll. *Niosh Health Hazard Evaluation Report: Heta #2004-0038-2966, Us Roofing Contractors*. 2005.
- Alternatives for Community & Environment Inc. *Environmental Justice and the Green Economy*. 2010.
- American Society of Safety Engineers. *The American Society of Safety Engineers Announces New Standard Project to Protect Workers in Wind Generation Construction Operations 2009*, accessed June 9 2010; Available from <http://www.asse.org/newsroom/release.php?pressRelease=1185>.
- \_\_\_\_\_. *ASSE Launches Prevention through Design Initiative, Holds Feb. Webinar 2010*, accessed June 9 2010; Available from <http://www.asse.org/newsroom/release.php?pressRelease=1384>.
- Baker, Greg, and Anthony Barsotti. "Procurement Methods to Facilitate Designing for Safety and Health." In *Designing for Safety and Health in Construction*, ed. Steven Hecker, John Gambatese and Marc Weinstein. Portland, Oregon, 2003.
- Balducci, Delight, Stephanie Haas, Cullen Howe, Kara Murphy, Giselle Vigneron, and Jason Wiener. *Green Jobs Position Paper: Green Jobs in New York: Where the (Green) Economy Meets the (Green) Environment* accessed May 17 2010; Available from.
- Behm, Michael. "Legal and Ethical Issues in Designing for Construction Safety and Health." In *Designing for Safety and Health in Construction*, ed. Steven Hecker, John Gambatese and Marc Weinstein. Portland, Oregon, 2003.

- Behm, Michael. "Linking Construction Fatalities to the Design for Construction Safety Concept." *Safety Science* 43, no. 8 (2005): 589-611.
- Behm, Michael, Thomas Lentz, Donna Heidel, and John Gambatese. "Prevention through Design and Green Buildings: A U.S. Perspective on Collaboration." In *CIB W099 Conference*. Melbourne, Australia, 2009.
- Bezdek, Roger. *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century*. Management Information Services for the American Solar Energy Society, 2007.
- Bishop, Lee, and Mitch Anstey. "Green Chemistry: Chemists Clean up Their Act." *Berkeley Science Review*, no. 16 (2009): 27-30.
- Brun, Becky, and Celeste LeCompte. *5 Nanotech Novelties 2007*, accessed May 3 2010; Available from <http://www.sustainableindustries.com/greenbuilding/6234871.html>.
- Buffa, Andrea, Carol Zabin, Cheryl Brown, and Dave Graham-Squire. *California's Global Warming Solutions Act of 2006: A Background Paper for Labor Unions*. University of California, Berkeley, Center for Labor Research and Education, 2008.
- Build It Green. "*Green*" *Fiberglass Insulation*. 2005.
- Bullard, Robert D. "Anatomy of Environmental Racism and the Environmental Justice Movement." In *Confronting Environmental Racism: Voices from the Grassroots*, ed. Robert D. Bullard, 15-39. Boston: South End Press, 1993.
- California Department of Public Health -- California Fatality Assessment and Control Evaluation (CA/FACE) Program. *California Face Report #08ca006: Laborer Dies When He Falls 35 Feet from a Scaffold after Being Electrocuted*. 2009.
- \_\_\_\_\_. *California Face Report #09ca003: An Electrical Worker Dies When He Falls through a Skylight While Installing Solar Panels on the Roof of a Warehouse*. 2009.
- Cha, Ariana Eunjung. "Solar Energy Firms Leave Waste Behind in China." *Washington Post*, March 9 2008, A01.
- Cheney, Ian. "The Greening of Southie." 72 minutes, 2008.
- Connecticut Council on Occupational Safety and Health. "4 G Jobs."

- Connelly, Mary Jo. *The Green Justice Solution: A Win-Win Plan to Prevent Climate Crisis and Jumpstart an Equitable and Sustainable Economic Recovery*. Green Justice Coalition and Community Labor United, 2008.
- CPWR - The Center for Construction Research and Training. *Construction Solutions, Database* accessed <http://www.cpwrconstructionsolutions.org/>.
- Delp, Linda, and Elizabeth Stewart. *Green Buildings, Good Jobs, Safe Jobs: Social Justice Pathways to a Sustainable Los Angeles*. Los Angeles: UCLA Community Scholars Program, 2009.
- Design for Construction Safety. *Prevention through Design* accessed 2010 May 18; Available from <http://www.designforconstructionsafety.org/media.shtml>.
- Dierdorff, Erich C., Jennifer J. Norton, Donald W. Drewes, Christina M. Kroustalis, David Rivkin, and Phil Lewis. *Greening of the World of Work: Implications for O\*Net-Soc and New and Emerging Occupations*. National Center for O\*NET Development, 2009.
- Environmental Defense Fund. *Green Jobs Guidebook: Employment Opportunities in the New Clean Economy*. 2008.
- Environments for Living. *Homebuyers & Homeowners Faqs* 2010, accessed May 27 2010; Available from [http://www.environmentsforliving.com/index.jsp?action=hb\\_faq#q](http://www.environmentsforliving.com/index.jsp?action=hb_faq#q).
- Finnegan, Amanda. "Two More Citycenter Structures Earn High Green Ratings." *Las Vegas Sun*, November 20 2009.
- Forest Stewardship Council. *The Fsc Principles and Criteria for Responsible Forest Management* accessed November 16 2009; Available from <http://www.fsc.org/pc.html>.
- Gambatese, John. "Safety Emphasis in University Engineering and Construction Programs." In *Designing for Safety and Health in Construction*, ed. Steven Hecker, John Gambatese and Marc Weinstein. Portland, Oregon, 2003.
- Gambatese, John A., Sathyanarayanan Rajendran, and Michael G. Behm. "Green Design & Construction: Understanding the Effects on Construction Worker Safety and Health." *Professional Safety, Journal of the American Society of Safety Engineers (ASSE)* (2007): 28-35.
- Gambatese, John, and Steve Hecker. "Collaboration in Design to Promote Construction Safety." In *14th Annual Construction Safety & Health Conference & Exposition*. Rosemont, IL, 2004.

- Gillen, Matt, Pietra Check, and Christine Branche. *Niosh Science Blog: Going Green: Safe and Healthy Jobs* 2010, accessed January 12 2010; Available from [http://www.cdc.gov/niosh/blog/nsb010410\\_green.html](http://www.cdc.gov/niosh/blog/nsb010410_green.html).
- Huang, Xinyu, and Jimmie Hinze. "Owner's Role in Construction Safety." *Journal of Construction Engineering and Management* 132, no. 2 (2006): 164-173.
- \_\_\_\_\_. "Owner's Role in Construction Safety: Guidance Model." *Journal of Construction Engineering and Management* 132, no. 2 (2006): 174-181.
- International Code Council. *International Green Construction Code* 2010, accessed June 14 2010; Available from <http://www.iccsafe.org/cs/igcc/pages/default.aspx>.
- Jones, Van. *The Green Collar Economy: How One Solution Can Fix Our Two Biggest Problems*. New York: HarperCollins, 2008.
- Krieger, Sari. "Half of Non-Residential Buildings Will Be Green by 2015 - Study." *Wall Street Journal* (2010).
- Labor Occupational Health Program at the University of California at Berkeley. "Safe Green Construction Curriculum." 2010.
- Lagos, Marisa. "State Adopts Greenest Building Codes in U.S." *San Francisco Chronicle*, January 13 2010.
- Las Vegas Sun. *Construction Deaths: Fatal Construction Accidents on the Strip* 2010, accessed May 4 2010; Available from <http://www.lasvegassun.com/news/topics/construction-deaths/>.
- Mattery, Philip, Alec Dubro, Thomas Gradel, Rachel Thompson, Kate Gordon, and Elena Foshay. *High Road or Low Road? Job Quality in the New Green Economy*. Good Jobs First, 2009.
- Michaels, David. "Making Green Jobs Safe: Integrating Occupational Safety & Health into Green and Sustainability." In *NIOSH Going Green Workshop*. Washington, DC, 2009.
- National Association of Home Builders. *National Green Building Standard* 2010, accessed May 27 2010; Available from <http://www.nahbgreen.org/Guidelines/ansistandard.aspx>.
- National Institute for Occupational Safety and Health. *Niosh Safety and Health Topic: Prevention through Design: Green, Safe and Healthy Jobs* accessed November 15 2009; Available from <http://www.cdc.gov/niosh/topics/PtD/greenjobs.html>.

National Institute of Occupational Safety and Health. *Niosh Safety and Health Topic: Prevention through Design* accessed <http://www.cdc.gov/niosh/topics/ptd/>.

\_\_\_\_\_. *Fatality Assessment and Control Evaluation (Face) Program: A Hispanic Maintenance Worker Dies after Falling through a Skylight* 2007, accessed <http://www.cdc.gov/niosh/face/stateface/ca/07CA007.html>.

\_\_\_\_\_. *Niosh Safety and Health Topic: Isocyanates*. 2010.

National Occupational Research Agenda (NORA) Construction Sector Council. *National Construction Agenda for Occupational Safety and Health Research and Practice in the U.S. Construction Sector*. National Institute of Occupational Safety and Health (NIOSH), 2008.

Nel, Andre, Tian Xia, Lutz Madler, and Ning Li. "Toxic Potential of Materials at the Nanolevel." *Science* 311 (2006).

New York Committee for Occupational Safety and Health. "Are Green Jobs Safe Jobs?" 2008.

Oregon OSHA. *Oregon Osha Releases Findings in Wind Turbine Collapse* 2008, accessed June 8 2010; Available from [http://www.orosha.org/admin/newsrelease/2008/nr2008\\_05.pdf](http://www.orosha.org/admin/newsrelease/2008/nr2008_05.pdf).

Oregon Solar Energy Industries Association. *Solar Construction Safety*. 2006.

OSHA Alliance Program -- Construction Roundtable. *Construction Workplace Design Solution: Falls from Roof Edge* 2010, accessed 2010 May 24; Available from [http://www.designforconstructionsafety.org/Documents/DS1%20-%20Falls%20From%20Roof%20Edge%20\(JM%20update%204-23-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS1%20-%20Falls%20From%20Roof%20Edge%20(JM%20update%204-23-10).pdf).

\_\_\_\_\_. *Construction Workplace Design Solution: Specify Non-Fragile Skylights and/or Skylight Guards* 2010, accessed May 24 2010; Available from [http://www.designforconstructionsafety.org/Documents/DS5%20-%20Skylight%20\(MG-TB%20update%205-3-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS5%20-%20Skylight%20(MG-TB%20update%205-3-10).pdf).

\_\_\_\_\_. *Construction Workplace Design Solution: Specify Sufficient Wall Height to Allow Parapets to Function as Fall Prevention* 2010, accessed May 24 2010; Available from [http://www.designforconstructionsafety.org/Documents/DS6%20-%20Parapets%20\(MG-TB%20update%205-3-10\).pdf](http://www.designforconstructionsafety.org/Documents/DS6%20-%20Parapets%20(MG-TB%20update%205-3-10).pdf).

Papp, Thilo, Dietmar Schiffmann, Dieter Weiss, Vince Castranova, Val Vallyathan, and Qamar Rahman. "Human Health Implications of Nanomaterial Exposure." *Nanotoxicology* 2, no. 1 (2008): 9-27.

- Pinderhughes, Raquel. *Green Collar Jobs*. The City of Berkeley Office of Energy and Sustainable Development, 2007.
- Pollin, Robert, Heidi Garrett-Peltier, James Heintz, Helen Scharber, Kit Batten, and Bracken Hendricks. *Green Recovery: A Program to Create Good Jobs and Start Building a Low-Carbon Economy*. Political Economy Research Institute (PERI) at University of Massachusetts-Amherst and Center for American Progress, 2008.
- Post, Nadine M. *Fly Ash Looms as the 'New Asbestos'* 2010, accessed May 10 2010; Available from.
- Rajendran, Sathyanarayanan. "Sustainable Construction Safety and Health Rating System." Oregon State University, 2006.
- Rajendran, Sathyanarayanan, and John Gambatese. "Development and Initial Validation of Sustainable Construction Safety and Health Rating System." *Journal of Construction Engineering and Management* 135, no. 10 (2009): 1067-1075.
- Rhode Island Committee on Occupational Safety and Health. *Going Green, Safely*.  
 \_\_\_\_\_. *Green During Construction* accessed June 8 2010; Available from <http://coshnetwork6.mayfirst.org/node/133>.
- Ruzek, Tim. "Man Burned While Working on Wind Turbine near Dexter." *Austin Post-Bulletin*, December 17 2008.
- Schwarzenegger, State of California -- Office of the Governor -- Arnold. *Press Release: Schwarzenegger Signs Legislation to Complete Million Solar Roofs Plan*. 2006.
- Sentz, Robert. *Green Pathways: A Data-Driven Approach to Defining, Quantifying, and Harnessing the Green Economy (Green Jobs, Part 3)*. Economic Modeling Specialists Inc., 2009.
- Silicon Valley Toxics Coalition. *Toward a Just and Sustainable Solar Energy Industry*. 2009. White Paper.
- Silins, Neil. "Leed & the Safety Profession: Green Has Come of Age." *Professional Safety* 54, no. 3 (2009): 46-49.
- SouthWest Organizing Project. *Environmental and Economic Justice* accessed February 24 2010; Available from <http://www.swop.net/environmental-justice>.
- State Building & Construction Trades Council of California. *Building Green Skills in California* 2010, accessed <http://www.youtube.com/watch?v=sh4SWBbr95g&feature=related>.

- Sumner, Steven A., and Peter M. Layde. "Expansion of Renewable Energy Industries and Implications for Occupational Health." *Journal of the American Medical Association* 302, no. 7 (2009): 787-798.
- The American Society of Heating Refrigerating and Air-Conditioning Engineers. *The Green Standard: Standard 189.1: Standard for the Design of High-Performance, Green Buildings* 2010, accessed June 10 2010; Available from <http://www.ashrae.org/publications/page/927>.
- The European Agency for Safety and Health at Work. 2010, accessed [http://osha.europa.eu/en/teaser/Files/20100525\\_project-overview-for\\_web\\_survey.pdf?utm\\_source=oshmail&utm\\_medium=email&utm\\_campaign=oshmail-96](http://osha.europa.eu/en/teaser/Files/20100525_project-overview-for_web_survey.pdf?utm_source=oshmail&utm_medium=email&utm_campaign=oshmail-96).
- The Green Building Initiative. *Ansi / Gbi Standard* 2010, accessed June 10 2010; Available from <http://www.thegbi.org/green-globes/ansi-gbi-standard.asp>.
- The Pew Charitable Trusts. *The Clean Energy Economy: Repowering Jobs, Businesses and Investments across America*. 2009.
- The United States Conference of Mayors, and Mayors Climate Protection Center. *U.S. Metro Economies: Current and Potential Green Jobs in the U.S. Economy*. 2008.
- The White House Task Force on the Middle Class -- Staff Report. *Green Jobs: A Pathway to a Strong Middle Class*. 2009.
- Toole, Michael T. "Rethinking Designers' Roles in Construction Safety." In *Designing for Safety and Health in Construction*, ed. Steven Hecker, John Gambatese and Marc Weinstein. Portland, Oregon, 2003.
- U.S. Occupational Safety and Health Administration. *Outreach Training Program Guidelines, Construction Industry Safety and Health* February 2009, accessed [http://www.osha.gov/dte/outreach/construction\\_generalindustry/construction.html](http://www.osha.gov/dte/outreach/construction_generalindustry/construction.html)
- U.S. Bureau of Labor Statistics. "Table 1.8 2008-18 National Employment Matrix, Industry Employment by Occupation (Construction 230000)." 2008.
- \_\_\_\_\_. *Table 5. Employment by Major Occupational Group, 2008 and Projected 2018*. 2008.
- U.S. Department of Health and Human Services -- Agency for Toxic Substances & Disease Registry. *Toxfaqs for Synthetic Vitreous Fibers*. 2004.

- U.S. Department of Labor Occupational Safety and Health Administration. *Accident Investigation Search, Inspection 307461855, Event Date 12/12/2006* accessed May 5 2010; Available from <http://www.osha.gov/pls/imis/accidentsearch.html>.
- U.S. Environmental Protection Agency. *Iaq Design Tools for Schools: Construction* accessed June 21 2010; Available from <http://www.epa.gov/iaq/schooldesign/construction.html>.
- \_\_\_\_\_. *Why Build Green?* accessed January 19 2010; Available from <http://www.epa.gov/greenbuilding/pubs/whybuild.htm>.
- \_\_\_\_\_. "Using Coal Ash in Highway Construction: A Guide to Benefits and Impacts." 2005.
- \_\_\_\_\_. *New Release: Epa Announces Plans to Regulate Coal Ash 2010*, accessed May 10 2010; Available from <http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/4eca022f6f5c501185257719005dfb1b!OpenDocument>.
- U.S. Green Building Council. *Intro - What Leed Measures* accessed February 1 2010; Available from <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1989>.
- \_\_\_\_\_. *Leed 2009 for New Construction and Major Renovations*. Washington, D.C., 2009.
- U.S. Green Building Council, and Booz Allen Hamilton. *Green Jobs Study*. 2009.
- United Nations Environment Programme. *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World*. 2008.
- Varble, Sarah Kleiner. "Man Injured after Fall inside Wind Turbine." *Abilene Reporter News*, April 16 2008.
- Washington State Department of Ecology. *Washington's Green Economy: Clean Energy and Other Industries at a Glance 2009*, accessed December 15 2009; Available from <http://www.ecy.wa.gov/climatechange/GreenEconomy.htm>.
- Washington State Employment Security Department. *2008 Green Economy Jobs in Washington State*. 2009.
- White, Sarah, and Jason Walsh. *Greener Pathways: Jobs and Workforce Development in the Clean Energy Economy*. Center on Wisconsin Strategy, 2008.
- Wilson, Michael P., Megan R. Schwarzman, Timothy F. Malloy, Elinor W. Fanning, and Peter J. Sinsheimer. *Green Chemistry: Cornerstone to a Sustainable California*.

The Centers for Occupational and Environmental Health, University of California, 2008.

Zarges, Tom, and Brad Giles. "Prevention through Design (Ptd)." *Journal of Safety Research* 39 (2008): 123-126.