Greening of the World of Work: Revisiting Occupational Consequences

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EXECUTIVE SUMMARY

Introduction

Delineating the ramifications of the green economy for occupations and occupational incumbents is essential for promoting national competitiveness in the global arena. Toward this end, we published a report in early 2009 entitled, *Greening of the World of Work: Implications for O*NET®-SOC and New and Emerging Occupations* (Dierdorff, Norton, Drewes, Kroustalis, Rivkin, & Lewis, 2009) that summarized a systematic review of the literature related to the green economy with a specific emphasis on pertinent occupational consequences. The purpose of the current effort is to assess the sustainability and impact of the concepts and definitions offered in the original 2009 report. In doing so, this report seeks to accomplish three primary goals. First, we review the broader literature in order to describe the current state of the world of work in relation to green economic activities. Second, we outline several major workforce development challenges facing the green economy from an occupational standpoint. Finally, we specifically discuss updated research pertaining to green new and emerging occupations.

This report is organized in five sections. Section I provides a brief synopsis of the prior 2009 report, a discussion of the sustainability and contributions of the occupational greening concept, and a description of several recent efforts to integrate the concept of occupational greening into other O*NET products and tools. Section II updates twelve different sectors of the green economy, including a description of the general sector activities, the degree and nature of any changes in activities and/or technologies since the 2009 report, and a comparison of the current workforce implications to those outlined in the 2009 report. Section III discusses several key challenges that coincide with the greening of occupations in the broader world at work. Section IV summarizes the results of a systematic review of 24 candidate green new and emerging occupations previously designated as “wait list” or as “do not recommend” during the research for the 2009 report. Finally, Section V provides a summary of the general conclusions of this report.

Impact of the 2009 Report

The past three years have seen a marked increase in the study of the consequences (or potential consequences) of green economy activities on work and jobs. Thus, it was important to review this recent work to compare and contrast the definitions offered in the 2009 report (i.e., occupational greening). Sources were identified and reviewed, and spanned three general sources.

- States or municipalities, such as reports from Illinois, Michigan, Missouri, and Oregon.
- Universities/colleges or non-profit research institutions, such as the Brookings Institution, and Work Information Council.
- Departments of the federal government, including the Economics and Statistics Administration (ESA) and the Bureau of Labor Statistics (BLS).

Two important conclusions resulted from reviewing these recent sources. First, the occupational greening concept offers a unique definitional approach that is more occupation-centric than other approaches, such as the BLS green jobs definition. For example, common across other definitional approaches is a central focus on the *output* or *consequences* that result from a given occupation on the green economy. This is an important distinction when compared to the concept of occupational greening, which emphasizes the impact of the green economy on *occupations themselves*. The second conclusion is that the occupational greening concept is best viewed as complementary to these other existing definitional approaches. In this sense, different definitional approaches provide unique perspectives as to the interplay between the green economy and occupations.

In addition to the evidence supporting the uniqueness of the occupational greening concept, other examples were found to suggest meaningful contributions. For example, the occupational greening concept appears to have impacted both research and practice in several forms.

- Use in numerous technical reports and survey research (e.g., Workforce Information Council, Georgetown University's Center on Education and the Workforce)
- Adoption by multiple state labor market and information offices (e.g., Tennessee, Indiana, Michigan, Missouri, and Iowa)
- Promotion of educational and training initiatives (e.g., Illinois Green Economy Network)
- Integration into career counseling and assessments (e.g., Strong Interest Inventory® and ASVAB Career Exploration Program®)

Finally, significant progress has been made to further research and develop the implications of occupation greening within the broader O*NET system. More specifically, three general developmental efforts have resulted.

- Data collection: 100 percent of green increased demand occupations have been fully updated during 2010 to 2011; 98 percent of green enhanced skill occupations have been fully updated in 2011; and, 35 percent of green new and emerging occupations have been fully updated since 2009.
- Data development: a total of 1,371 green tasks across the 138 green enhanced skill and green new and emerging occupations have been generated.

- Data compilation and review: compendium of references is regularly updated (*Greening of the World of Work: O*NET Project's Book of References*) and the occupational greening concept has been integrated into other O*NET products and tools O*NET OnLine (www.onetonline.org), O*NET Academy (www.onetacademy.org), O*NET Database (www.onetcenter.org/database.html), My Next Move (www.mynextmove.org), and My Next Move for Veterans (www.mynextmove.org/veterans/).

Green Sector Updates

A review of green research conducted since 2009 suggested that the 12 green sectors previously identified in the 2009 report were comprehensive and no new sector additions were required. Table 1 below provides a brief snapshot of the current state of each sector with respect to recent technological innovations, overall sector growth, and workforce implications. More detailed information about each green sector can be found in the body of this report (see Section II).

Table 1. Summary of Green Sectors

Sector	Current State
Renewable Energy Generation	High level of activity [a]
Transportation	Moderate level of activity
Energy Efficiency	Moderate level of activity
Green Construction	Moderate level of activity
Energy Trading	Low level of activity
Energy and Carbon Capture and Storage	Low level of activity
Research, Design, and Consulting Services	Moderate level activity
Environment Protection	Moderate level of activity
Agriculture and Forestry	Moderate level of activity
Manufacturing	Low level of activity
Recycling and Waste Reduction	High level of activity
Governmental and Regulatory Administration	Moderate level of activity

Note. [a] some areas in this sector are showing more activity (e.g., solar and wind) than others (e.g., biomass)

Updated research on the green sectors also suggested that the 62 occupations identified as green enhanced skills in 2009 continue to be relevant in today's green economy. Further, evidence did not suggest any major developments since 2009 in green economic activities or technologies to warrant the need for new additions to this list. Similarly, current evidence supports the continued viability of the 78 green new and emerging occupations previously identified. Finally, occupations designated as "wait list" or as "do not recommend (DNR)" in the 2009 report were revisited to assess their current viability. Of these 24 candidate occupations for new and emerging status, the cumulative evidence since the 2009 report suggested five status change recommendations listed below in Table 2.

Table 2. Status of Candidate New and Emerging Occupations

Candidate	Status	Recommendation
Solar Resource Assessors	DNR	Remove as candidate N&E
Residential Air Sealing Technicians	DNR	Remove as candidate N&E
Testing Adjusting and Balancing TAB Technicians	DNR	Consider upgrading to green N&E
Research and Development Engineers	DNR	Remove as candidate N&E
Organic Farmers	DNR	Consider upgrading to green N&E

Future Challenges of Occupational Greening

Several challenges to continued growth of green economic activities and technologies have been outlined in the broader literature. These include needs for human, financial, and technological investment as well as more coordinated inter-agency efforts. In addition, some authors point to the need for stronger domestic responses to increasing global competition in manufacturing and deployment of green technologies. In their 2011 report, Muro et al. summarized many of these domestic imperatives by concluding:

> *"As to what governments, policymakers, and regional leaders should do to catalyze faster and broader growth across the U.S. clean economy, it is clear that the private sector will play the lead role, but governments have a role too. In this connection, the fact that significant policy uncertainties and gaps are weakening market demand for clean economy goods and services, chilling finance, and raising questions about the clean innovation pipeline reinforces the need for engagement and reform. Not only are other nations bidding to secure global production and the jobs that come with it but the United States currently risks failing to exploit growing world demand. [Thus]*

…vigorous private sector-led growth needs to be co-promoted through complementary engagements by all levels of the nation's federal system to ensure the existence of well-structured markets, a favorable investment climate, and a rich stock of cutting-edge technology—as well as strong regional cast to all efforts."

Yet, for human or intellectual capital development efforts to be most effective they must be based on a systematic assessment of training needs (i.e., the focal competencies of importance). Thus, the overarching challenge here is the development of a domestic system that identifies the essential competencies requisite to occupational roles within the green economy. This would entail several key outcomes. First, there is a clear need for more concise definitions of what such "green skills" are meant to encompass (i.e., which worker attributes). Second, there is a need for a systematic organization of green skills or competencies. Lastly, any domestic effort at identifying key green skills or competencies should strive to describe the linkages or crosswalks to existing national occupational information systems such as O*NET.

SECTION I: INTRODUCTION AND OVERVIEW

Section I-A: Statement of Purpose and Goals

The past decade has witnessed considerable growth in the literature regarding the various economic, societal, and technological implications of the green economy, where such activities include reducing the use of fossil fuels, decreasing pollution and greenhouse gas emissions, increasing the efficiency of energy usage, recycling materials, and developing and adopting renewable sources of energy. Delineating the ramifications of the green economy for occupations and occupational incumbents is, from a workforce development perspective, essential for promoting national competitiveness in the global arena. Toward this end, we published a report in early 2009 (see *Greening of the World of Work*; Dierdorff et al., 2009) that summarized a systematic review of the literature related to the green economy with a specific emphasis on pertinent occupational consequences.

Since the publication of the 2009 report, the broader world of work has witnessed significant changes. The global economic recession has resulted in a general decline in employment and substantial reductions in public and private investment. These economic conditions have certainly impacted overall growth in sectors related to green economic activity as well (Strietska-Ilina, Hofmann, Durán Haro, & Jeon, 2011). Despite these challenging conditions, several noteworthy trends and developments pointing to possible future growth in the green economy have also occurred. For example, the past three years have seen an increase in the attention given to more accurate measurement and accounting of green economic activities by agencies such as the U.S. Department of Labor Bureau of Labor Statistics and the International Labour Organization. In addition, more focused domestic research, especially at the state level, has been undertaken to assess the impact of green economic activities and technologies on employment, occupations, and educational needs. Finally, major federal legislation in the *American Recovery and Reinvestment Act* (ARRA) aimed at overall economic stimulus has been introduced and included provisions that specifically impacted areas of the green economy (e.g., renewable energy, environmental remediation, research and development).

With these important developments in mind, the general purpose of the present report is to assess the sustainability and impact of the concepts and definitions offered in the original 2009 report. In doing so, the present report seeks to accomplish three primary goals. First, we review the broader literature in order to describe the current state of the world of work in relation to green economic activities. Here, we emphasize comparisons to our prior report including any important changes and trends occurring over the past three years. Second, we outline several major workforce development challenges facing the green economy from an occupational standpoint. Finally, we

specifically discuss updated research pertaining to green new and emerging occupations. In the section below we begin by providing a brief discussion of the key contributions of the 2009 report.

Section I-B: Brief Synopsis of 2009 Greening of the World of Work Report

The primary purpose of the 2009 report was to investigate the impact of green economy activities and technologies on occupational requirements in an effort to determine their impact on O*NET-SOC occupations already included in the O*NET database as well as to identify any new and emerging occupations being generated. In addition to providing an integrative definition of the green economy based upon the broader literature, the report also sought to offer more discrete descriptions of the types of effects the green economy holds at the occupational level. In particular, we took a more bounded definitional approach wherein the *label* of "green" was replaced with an emphasis on the *process* of "greening." As shown in the definition below, this approach enabled us to shift focus away from simply labeling occupations as "green" and to instead concentrate on the differential effects of the green economy on occupations.

> The "greening" of occupations refers to the extent to which green economy activities and technologies increase the demand for existing occupations, shape the work and worker requirements needed for occupational performance, or generate unique work and worker requirements.

We further delineated three general occupational categories to depict the differential consequences of green economy activities and technologies on occupational performance. These categories were as follows:

> *Green Increased Demand Occupations*. The impact of green economy activities and technologies is an increase in the employment demand for an existing occupation. However, this impact does not entail significant changes in the work and worker requirements of the occupation. The work context may change, but the tasks themselves do not.
>
> *Green Enhanced Skills Occupations*. The impact of green economy activities and technologies results in a significant change to the work and worker requirements of an existing O*NET-SOC occupation. This impact may or may not result in an increase in employment demand for the occupation. The essential purposes of the occupation remain the same, but tasks, skills, knowledge, and external elements, such as credentials, have been altered.
>
> *Green New and Emerging Occupations*. The impact of green economy activities and technologies is sufficient to create the need for unique work and worker

requirements, which results in the generation of a new occupation relative to the O*NET taxonomy. This new occupation could be entirely novel or “born” from an existing occupation.

To investigate the nature of occupational greening in the broader world of work, we identified 12 major sectors of the green economy from a comprehensive review of the extant literature. These sectors are listed below with their associated descriptions.

1. Renewable Energy Generation. This sector covers activities related to developing and using energy sources such as solar, wind, geothermal, and biomass.

2. Transportation. This sector covers activities related to increasing efficiency and/or reducing the environmental impact of various modes of transportation including trucking, mass transit, freight rail, and so forth.

3. Energy Efficiency. This sector covers activities related to increasing energy efficiency (broadly defined), making energy demand response more effective, constructing “smart grids,” and so forth.

4. Green Construction. This sector covers activities related to constructing new green buildings, retrofitting residential and commercial buildings, and installing other green construction technology.

5. Energy Trading. This sector covers financial services related to buying and selling energy as an economic commodity, as well as carbon trading projects.

6. Energy and Carbon Capture and Storage. This sector covers activities related to capturing and storing energy and/or carbon emissions, as well as technologies related to power plants using the integrated gasification combined cycle (IGCC) technique.

7. Research, Design, and Consulting Services. This sector encompasses “indirect jobs” in the green economy, which includes activities such as energy consulting or research and other related business services.

8. Environment Protection. This sector covers activities related to environmental remediation, climate change adaptation, and ensuring or enhancing air quality.

9. Agriculture and Forestry. This sector covers activities related to using natural pesticides, efficient land management or farming, and aquaculture.

10. Manufacturing. This sector covers activities related to industrial manufacturing of green technology as well as energy efficient manufacturing processes.

11. Recycling and Waste Reduction. This sector covers activities related to solid waste and wastewater management, treatment, and reduction, as well as processing of recyclable materials.

12. Governmental and Regulatory Administration. This sector covers activities by public and private organizations associated with conservation and pollution prevention, regulation enforcement, and policy analysis and advocacy.

These sectors were then researched to determine the nature of green activities and technologies requisite to each and, more importantly, to uncover any pertinent workforce implications. This research culminated in the identification of occupations falling into the three greening categories described earlier. Specifically, 64 O*NET-SOC occupations were found to qualify as “green increased demand” occupations, 62 O*NET-SOC occupations were found to qualify as “green enhanced skills” occupations, and 78 O*NET-SOC occupations were found to qualify as “green new and emerging” occupations. Appendices A-C list the 204 occupations as well as their associated green sectors and occupational greening category.

Section I-C: Sustainability and Contribution of the Occupational Greening Concept

The central goal in originally developing the concept of greening was to promote an operational definition of the types of impacts that green economic activities and technologies might have on occupations in the national workforce. Such an operational definition is essential for occupational analysis in general, and strategic workforce development in particular, as it informs specific education, training, and career transitioning initiatives. These broad uses are also fundamental to a national occupational information system such as O*NET and thus shaped the unique approach that was undertaken when defining and researching the green economy in the 2009 report. Because the primary emphasis was on occupational implications, the concept of occupational greening was not intended to be equally applicable across the wide variety of needs related to analyzing the green economy. For example, the notion of occupational greening emphasizes the importance of changes to work and/or worker requirements of occupations, rather than focusing on broader “counts” of incumbents and establishments that comprise the green economy. With these issues in mind, it is valuable to assess the impact of the occupational greening concept since its introduction, as well as to compare and contrast this concept to other recent definitional approaches.

To develop our original working definition of occupational greening, we reviewed more than 60 publications on various workplace topics relevant to the green economy. One striking conclusion from this review was the substantial variability in definitional approaches, which ranged in both content and specificity. Put simply, as was the case

with other researchers at the time (e.g., Environmental Defense Fund, 2008), we did not find a commonly accepted definition of what constituted a “green job.” We thus sought to integrate the approaches from this existing literature (prior to 2009), while offering a more parsimonious definition that highlighted the impact of the green economy on occupations. Along these lines, it is important to examine the definitional approaches employed in more recent literature (since 2009) in order to depict how concepts of “green jobs or occupations” may have evolved.

Indeed, the past three years have seen a marked increase in the study of the impact (or potential impact) of green economy activities on work and jobs. For the most part, these efforts have originated from three general sources: (1) states or municipalities; (2) universities/colleges or non-profit research institutions; and, (3) departments of the federal government. With regard to the first source category, most descriptions are bounded by a specific emphasis on within-state activity, such as particular industries or sectors prevalent in a given region. Below are examples of definitional approaches from several reports sponsored or authored by state and municipality agencies.

> “Missouri defines green jobs as those directly involved in generating or supporting a firm’s green-related products or services. The state’s green economy is defined as being comprised of industries that provide green products or services in six areas: Energy, Manufacturing, Building, Farming, Salvage/Remediation, and Government.” (Missouri Economic and Research Information Center, 2009).

> “The state [New Mexico] defines green jobs as family-supporting, career-track jobs that directly contribute to preserving or enhancing environmental quality.” (New Mexico Green Jobs Cabinet, 2009)

> “A green job [is] one that provides a service or produces a product in: 1. increasing energy efficiency; 2. producing renewable energy; 3. preventing, reducing, or mitigating environmental degradation; 4. cleaning up and restoring the natural environment; 5. providing education, consulting, policy promotion, accreditation, trading and offsets, or similar services supporting categories 1-4.” (Workforce Oregon, 2009).

> “Michigan defines green jobs as jobs directly involved in generating or supporting a firm’s green related products or services … comprised of industries that provide products or services in five areas: agriculture and natural resource conservation, clean transportation and fuels, increased energy efficiency, pollution prevention or environmental cleanup, and renewable energy production.” (Michigan Department of Energy, Labor, and Economic Growth, 2009).

> “A job in which the work is essential to products or services that improve energy efficiency, expand the use of renewable energy, or support environmental sustainability.” (Illinois Department of Employment Security, 2011).

> "Green collar jobs are …career-track employment opportunities in emerging environmental industries as well as conventional businesses and trades, created by a shift to more sustainable practices, materials, and performance. It includes both lower and higher skilled employment opportunities that minimize the carbon footprint of all inputs necessary and directly results in the restoration of the environment, generation of clean energy and improved energy efficiency, creation of high performance buildings, conservation of natural resources." (District of Columbia, 2009).

Examples of recent definitional approaches from the second category (universities/colleges or non-profit research institutions) are shown below. In general, the approaches from this source category tend to be rather broad in scope and detail, although there is also substantial variability across individual sources. Many of these definitions emphasize the impact on society or the conditions created by green jobs.

> "A Green Job is an occupation that (1) directly works with policies, information, materials, and/or technologies that contribute to minimizing environmental impact, and (2) requires specialized knowledge, skills, training, or experience in these areas." (California Community Colleges Association, 2009)

> "Green jobs enhance environmental quality, build a vibrant clean energy economy, and help to expand the American middle class." (Hendricks, Light, & Goldstein, 2009).

> "A green job is one in which the work is essential to products or services that improve energy efficiency, expand the use of renewable energy, or support environmental sustainability." (Workforce Information Council, 2009).

> "Green-collar jobs are well-paid, career track jobs that contribute directly to preserving or enhancing environmental quality. If a job improves the environment, but doesn't provide a family-supporting wage or a career ladder to move low-income workers into higher-skilled occupations, it is not a green-collar job." (Green for All, 2011)

> "The clean economy is economic activity—measured in terms of establishments and the jobs associated with them—that produces goods and services with an environmental benefit or adds value to such products using skills or technologies that are uniquely applied to those products." (Muro, Rothwell, & Saha, 2011)

Finally, since 2009 several departments and/or agencies of the federal government have published reports pertaining to jobs within the green economy. These definitional approaches tend to emphasize measurability in order to fulfill the primary purposes of

the research, which typically entails estimating various labor statistics or indices of economic output. For example, the U.S. Department of Commerce Economics and Statistics Administration defined green jobs as those associated with

> "Green products or services … whose predominant function serves one or both of the following goals. [1] Conserve energy and other natural resources: this includes products or services that conserve energy to reduce fossil fuels and promote water, raw material, land, species and ecosystem conservation; or [2] Reduce pollution: this includes products or services that provide clean energy or prevent, treat, reduce, control or measure environmental damage to air, water and soil. The remediation, abatement, removal, transportation, or storage of waste and contaminants also are considered to reduce pollution." (U.S. Department of Commerce, 2010)

The U.S. Department of Labor Bureau of Labor Statistics takes a similar environmental impact approach, whereby green jobs are defined as either:

> "A. Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources. [Or] B. Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or use fewer natural resources." (U.S. Department of Labor Bureau of Labor Statistics, 2010)

One commonality across the definitional approaches described above is a central focus on the output or consequences of a given occupation. This is important and valuable, as it helps to quantify the total economic impact on the broader labor market and national economy. This focus also represents a key definitional distinction compared to our conceptualization of the greening of occupations. Specifically, the approaches above emphasize the consequences or output of occupations on the green economy, whereas the occupational greening concept emphasizes the impact of the green economy on occupations themselves. This is an important difference because it portrays the uniqueness of the occupational greening concept, which takes a decidedly occupation-centric approach. Here, consequences of the green economy for occupations are the primary interest; whether it is simply growth in employment demand, changes in the way existing occupations are performed, or creation of a unique or new occupation in the workforce.

In this sense, the occupational greening concept is best viewed as complementary to these other definitional approaches. That is, each approach provides a unique perspective as to the interplay between the green economy and occupations. Thus, the choice of definitional approach should depend upon the ultimate purpose or use. For instance, the occupational greening concept becomes particularly salient when the purpose is to understand how occupations are affected by green economy activities and technologies, such as ascertaining shifting and/or new demands in terms of work (task and responsibilities) and worker requirements (knowledge, skills, or abilities). On the

other hand, the concept of occupational greening becomes less salient when the general purpose is to assess labor market statistics.

Beyond this unique definition is a related question of the relative contribution to the broader green economy literature. That is, gauging the value of the occupational greening concept from both a research and a practical perspective. The available evidence appears supportive of the idea that the occupational greening concept has made meaningful contributions. Here, the occupational greening concept has been used in numerous technical reports and survey research, as well as adopted by multiple state labor market and information offices. For example, the Workforce Information Council (WIC) and Georgetown University's Center on Education and the Workforce (CEW) both reference occupational greening in their recent reports (CEW, 2010; WIC, 2009). Research and labor information systems sponsored by the states of Tennessee, Indiana, Michigan, Missouri, and Iowa have all built their efforts and results on the occupational greening concept and the green sectors identified in the 2009 report (Iowa Workforce Development, 2011; Missouri Economic Research & Information Center, 2009; TN Department of Labor & Workforce Development, 2011; Slaper, 2011). The occupational greening concept has also influenced the initiatives of educational and training organizations. For example, Illinois has used the occupational greening as a centerpiece in building inter-organizational partnerships across community colleges (IGEN, 2011). Finally, the occupational greening categories have been integrated into several career counseling and assessments. For instance, The Career Key®, the Strong Interest Inventory®, and the ASVAB Career Exploration Program® have all incorporated occupational greening (Anderson & Herk, 2011; ASVAB, 2010; Careerkey.org).

Section I-D: Further Progress on Occupational Greening: Recent O*NET Developments

Since the 2009 report several initiatives have been undertaken to further research and develop O*NET data and tools pertaining to the occupational greening concept. These are briefly summarized below and, when applicable, illustrative examples are provided. More detailed explanation and data are available from the O*NET Resource Center website (www.onetcenter.org).

One significant development since 2009 has involved data collection and updating of occupations across the three categories of occupational greening. Here, every occupation previously identified as green increased demand, green enhanced skill, or green new and emerging has been updated with data collection and/or data augmentation. In other words, 100 percent of these occupations have undergone recent efforts to ensure current occupational information. For instance, 100 percent of the green increased demand occupations have been fully updated by new data collection over the past two years (2010-2011). Of the green enhanced skill occupations, all occupations except one (98 percent) have been fully updated in 2011 alone. The single

exception (11-9013.02 Farm and Ranch Managers) still received partial updating, which included data augmentation with the addition of new task data. Just over one third (35 percent) of the new and emerging occupations associated with the green economy have been fully updated since 2009, and the remaining occupations in this grouping have all received partial data updates in this same time period. Appendices A-C provide more detailed information regarding the status of data collection and updates for all of the green increased demand, green enhanced skill, and green new and emerging occupations to date.

Another substantial development has been to generate new task data that depicts the new kinds of work behavior coinciding with green economic activities and technologies. In particular, this task development effort focused on green enhanced skill and green new and emerging occupations because these are the occupational roles for which the impact of the green economy results in changes to work and worker requirements and the generation of unique work and worker requirements. In order to reflect such changes, a task development process was developed and implemented (see O*NET Green Task Development Project for more details). Table 3 below provides several illustrative examples of green tasks generated across several occupations. To date, this task development project has produced a total of 1,369 green tasks across the 138 green enhanced skill and green new and emerging occupations. Appendices D-E provide a full listing of these tasks and their associated occupations.

Table 3. Sample Green Tasks

Occupation	**Sample Green Tasks**
Chief Sustainability Officers	Conduct sustainability- or environment-related risk assessments. Develop methodologies to assess the viability or success of sustainability initiatives. Direct sustainability program operations to ensure compliance with environmental or governmental regulations.
Energy Brokers	Answer customer questions related to energy sales procedures, energy markets, or alternative energy sources. Analyze customer bills and utility rate structures to select optimal rate structures for customers.
Environmental Economists	Assess the costs and benefits of various activities, policies, or regulations that affect the environment or natural resource stocks. Collect and analyze data to compare the environmental implications of economic policy or practice alternatives. Conduct research on economic and environmental topics, such as alternative fuel use, public and private land use, soil conservation, air and water pollution control, and endangered species protection.

Occupation	Sample Green Tasks
Water Resource Specialists	Analyze storm water systems to identify opportunities for water resource improvements. Develop plans to protect watershed health or rehabilitate watersheds.
Precision Agriculture Technicians	Apply precision agriculture information to specifically reduce the negative environmental impacts of farming practices. Provide advice on the development or application of better boomspray technology to limit the over-application of chemicals and to reduce the migration of chemicals to areas other than the fields being treated.
General and Operations Managers	Manage the movement of goods into and out of production facilities to ensure efficiency, effectiveness, or sustainability of operations. Implement or oversee environmental management or sustainability programs addressing issues such as recycling, conservation, or waste management.
Regulatory Affairs Managers	Monitor regulatory affairs activities to ensure that they are aligned with corporate sustainability or green initiatives. Monitor regulatory affairs trends that are related to environmental issues.
Logistics Managers	Implement or monitor carbon or environmental management, accounting, or audit systems. Negotiate with suppliers or customers to improve supply chain efficiency or sustainability. Prepare or file environmental certification applications.
Transportation Vehicle, Equipment and Systems Inspectors, Except Aviation	Compare emissions findings with applicable emissions standards. Perform low-pressure fuel evaluative tests (LPFET) to test for harmful emissions from vehicles without onboard diagnostics (OBD) equipment.
Machinists	Dispose of scrap or waste material in accordance with company policies and environmental regulations. Separate scrap waste and related materials for reuse, recycling, or disposal.
Hazardous Materials Removal Workers	Identify or separate waste products or materials for recycling or reuse. Process e-waste, such as computer components containing lead or mercury.

In addition to data collection and task development efforts, ongoing review and compilation of information about the green economy has been, and continues to be, conducted. For example, a regularly updated compendium of references organized by the 12 green sectors is available through the O*NET website (see *Greening of the*

*World of Work: O*NET Project's Book of References*; O*NET, 2011). This source is intended to assist users in learning more about the greening of the world of work and includes references such as articles, books, trade publications, technical reports, and relevant websites. Further, the occupational greening concept has been integrated into the O*NET OnLine system (www.onetonline.org), which allows for searchable inquires across the green sectors and occupational greening categories, as well as other O*NET tools and products such as the O*NET Academy (www.onetacademy.org), My Next Move (www.mynextmove.org), and My Next Move for Veterans (www.mynextmove.org/vets/).

SECTION II: DESCRIPTIVE UPDATES BY GREEN SECTOR

The 12 green sectors previously presented are summarized in this section. The primary purpose of these synopses is to provide snapshots of general sector activities, the degree and nature of any changes in activities and/or technologies since the 2009 report, and a comparison of the current workforce implications compared to those outlined in the 2009 report. More detailed information pertinent to the following green sector synopses may be found in this report's appendices, which are referenced throughout this section. For example, Appendices A-C provide a full listing of green increased demand, green enhanced skill, and green new and emerging occupations. These listings provide occupational descriptions and green sector affiliations. Appendices F-G provide specific employment projections estimated by the U.S. Bureau of Labor Statistics (BLS) for green increased demand and green enhanced skill occupations. BLS projections for the green new and emerging occupations are not included, as these particular occupational titles have yet to be subject to specific estimations. For purposes of comparison, 10-year estimates are provided from earlier projections (2006-2016) and from recent projections (2008-2018).

It is important to note that the identification of the 12 sectors in the previous report was based on an extensive review of the existing literature. An additional examination and review of reports since 2009 did not offer any new sectors that were not already subsumed by the original list of 12. Table 4 below provides examples of the coverage of 12 sectors relative to green sectors discussed in several more recent reports.

Table 4. Green Sector Coverage

Recent Reports	**Green Sectors**
Muro et al. (2011) – Brookings Institute Agricultural and Natural Resources Conservation Education and Compliance Energy and Resource Efficiency Greenhouse Gas Reduction, Environmental Management and Recycling Renewable Energy	1, 3, 6, 7, 8, 9, 11, 12
Chapple & Hutson (2010) Energy Research and Services Environmental Services Green Building Green Manufacturing Green Transportation Recycling and Remediation	1, 2, 3, 4, 7, 8, 10, 11
Strietska-Ilina et al., (2011) – International Labour Organization Administration and Management Building Business and Financial Services Education and Training Services Manufacturing Recycling and Material Management Renewable Energy Retail Tourism Transport and Logistics Waste and Water Management	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Recent Reports (cont.)	Green Sectors
Work Information Council (2009) Renewable Energy and Alternative Fuels Energy Efficiency and Conservation Pollution, Waste, and Greenhouse Gas Management, Prevention, and Reduction Environmental Cleanup and Remediation and Waste Cleanup and Mitigation Sustainable Agriculture and National Resource Conservation Education, Regulation, Compliance, Public Awareness, and Training and Energy Trading	1, 3, 5, 6, 7, 8, 9, 11, 12

1. Renewable energy generation; 2. Transportation; 3. Energy efficiency; 4. Green construction; 5. Energy trading; 6. Energy and carbon capture and storage; 7. Research, design, and consulting services; 8. Environmental protection; 9. Agriculture and forestry; 10. Manufacturing; 11. Recycling and waste reduction; 12. Governmental and regulatory administration.

Section II-1: Renewable Energy Generation

As evidenced in Table 4 above, this sector remains at the heart of most green economy discussions and research. Moreover, renewable energy production is central to the definitional approaches agencies have taken in relation to green jobs (e.g., Department of Commerce ESA and Department of Labor BLS). Government regulations, energy costs, climate change, and the depletion of natural resources are all factors driving growth and change in this sector. As of 2010, 37 states and the District of Columbia have enacted regulations ("renewable portfolio standards") that require a particular portion of electricity to be generated from renewable sources, a 64 percent increase from 24 states in 2008 (Energy Information Administration [EIA], 2010). Such renewable energy sources include wind, solar, geothermal, hydropower, biomass, and hydrogen (Green Jobs Guidebook, 2008; Perry, 2008; Pollin et al., 2008; Pollin & Wicks-Lim, 2008; White & Walsh, 2008). It has been estimated that total net renewable power generation accounts for approximately 11 percent of total domestic power generation. (EIA, 2011) Each of these renewable sources is briefly described below.

Wind

Energy derived from wind is commonly used for a variety of purposes such as generating electricity, charging batteries, pumping water, or grinding grain. As of 2010, wind provides about 2 percent of total U.S. electricity generation and 17 percent of total renewable energy generation (EIA, 2010). Over the past 5 years, 400 new

manufacturing facilities have been added or expanded in the U.S. (American Wind Energy Association, 2011a; Gelsi, 2011). With regard to employment, the American Wind Energy Association has estimated that as of 2010 the wind energy sector domestically employs roughly 75,000 full-time workers (American Wind Energy Association, 2011b).

While many of the basic wind energy technologies have remained the same since 2009, several research efforts are underway to develop new technologies that seek to increase efficiency and output. Examples include new blade designs and intelligent turbine controllers (AENews Network, 2011), increasing the size of the individual wind turbines in a wind energy installation (AENews Network, 2010c), and exploring new types of turbines such as bladeless or airborne kite-like structures (AENews Network, 2010a; 2010b).

In terms of projected growth in this sector, the Department of Energy recently concluded:

> With federal incentives for wind energy in place through 2012, an improved project finance environment, and lower wind turbine and wind power pricing, modest growth in annual wind power capacity appears likely … [but] are expected to remain well below the 2009 high, however, due in part to relatively low wholesale electricity prices and limited need for new electric capacity additions, and in part to existing state-level RPS programs that, in aggregate, are not sizable enough to support continued wind power capacity additions at 2008 and 2009 levels … Most projections show further growth in 2012, as the cost of wind energy continues to decline as a result of lower wind turbine pricing, and as wind project developers rush to capture federal incentives currently slated to expire at the end of that year. Forecasts for 2013, meanwhile, span a particularly wide range, depending in part on assumptions about the possible extension of federal incentives beyond 2012, but in general are weighed down by current policy uncertainty as well as the expected limited need for new electric capacity additions (U.S. Department of Energy, 2011a).

Solar

Solar power production has grown substantially since 2006, when only two states had central station capacity (California and Arizona). As of 2010, a total of 15 states have such capacity, a more than seven-fold increase (EIA, 2010). A critical component in the use of solar power is photovoltaic technology, which comprises the electricity-generating layers of silicon between solar panels. Until recently, this equipment has been considered too cost-prohibitive to compete with traditional power generation methods. In addition to photovoltaic cells, solar power innovations include concentrating solar power (CSP) technologies and low temperature solar collectors. While photovoltaic cells convert sunlight directly into electricity, CSP or solar thermal

technologies use reflective materials to increase the concentration of the sun's energy. CSP technologies utilize mirror-covered dishes that rotate throughout the day to track the sun and subsequently heat hydrogen to drive generator pistons that produce electricity. Such dishes are becoming more affordable and their use has been demonstrated for some time in states such as California (EIA, 2004). In addition, current research and development efforts have focused on integrating nanotechnology (e.g., carbon nanotubes) for improved solar cells (Science Daily, 2011). General Electric has also recently developed a highly efficient "thin film" solar cell composed of cadmium-telluride (Shahan, 2011).

In terms of projected growth in this sector, a recent report authored by the Solar Foundation concluded:

> As of August 2011, the National Solar Jobs Census 2011 identified more than 17,198 solar employment sites and 100,237 solar jobs in all 50 states. The solar industry's job growth rate of 6.8 percent is significantly higher than the 2 percent net job loss in fossil fuel power generation and the economy-wide expectation of 0.7 percent growth over the same period…. solar employers expect to increase the number of solar workers by 24 percent, representing nearly 24,000 net new jobs by August 2012. Over the next 12 months, nearly half of solar firms expect to add jobs (The Solar Foundation; 2010).

Geothermal

Energy from this renewable source is obtained from the heat of the Earth tapped at various depths ranging from shallow ground, to hot water and rock a few miles below the ground, to deeply buried magma. Hot water or steam sources are typically used to supply steam turbines that, in turn, generate electricity. (Geothermal energy is recognized as very reliable and cost-effective. However, geothermal plants must be located in very specific areas, such as those with volcanic activity, tectonic plate shifting, or major hot springs and geysers. Technological innovation is available to help ameliorate issues of location specificity. Hot Dry Rock Geothermal Energy (HDRGE) is one such technology and allows geothermal plants to be located almost anywhere (Plunkett Research Online, 2005) Such enhanced geothermal systems involve increasing the permeability of rock and then injecting water so that it can be heated to generate energy (Department of Energy, 2011b). Research projects are also pursuing areas such as advanced exploratory drilling techniques, improved geophysical exploration techniques involving technologies such as remote sensing, and new well construction technologies (Renewable Energy World, 2011).

As of 2010, the Geothermal Energy Association (GEA) estimated that the industry supports roughly 5,200 direct jobs related to geothermal power production and management, and approximately 13,100 full-time jobs when direct and indirect jobs are totaled (Jennejohn, 2010). The GEA further expects employment to increase as

geothermal plant development and research expands. Currently, 146 geothermal projects across 15 different states are under development (SustainableBusiness.com, 2011). The number of U.S states with geothermal plants has quadrupled since 2005 and total employment (direct and indirect jobs) has grown by 30 percent since 2008 (Wagner, 2011).

Hydropower

According to the Electric Power Supply Association, hydroelectric facilities currently generate enough power to supply 72-96 million households with electricity and, because electricity is generated using water, there is little air pollution. Thus, hydroelectric power is considered to be one of the most reliable, cost effective, and controllable sources of renewable energy. However, there are some limits on its potential for expanded use beyond facilities already in operation today. For example, there are very few potential locations for new hydrodams. In addition, droughts that often occur in the Western U.S. can create problems for hydropowered electricity generation. Finally, associated adverse effects of waterway damming, such as altering the habitats of local plant, fish, and animal life, have made them less attractive energy sources. To counter the adverse environmental effects of hydropower, several new technologies are under development. For example, advanced turbine systems are said to have benefits such as reduced fish mortality, improved compliance with water quality standards, and reductions in carbon dioxide emissions (Idaho National Laboratory, 2007). In addition, hydrokinetics and wave power are key innovations thought to become more influential in the future (Hydrokinetic News, 2011).

Hydropower represented the largest share of the renewable-generated electricity in 2009 (about two-thirds) (EIA, 2009). This share is predicted to grow to nearly 55 percent of total renewable energy production by 2035 (HydroWorld, 2011). In terms of overall contributions, hydropower provides nearly 7 percent of the nation’s electricity production and is estimated to employ between 200,000 and 300,000 individuals in project development and deployment, manufacturing, operations, and maintenance (Environmental and Energy Study Institute, 2011).

Biomass

Biomass resources produce an array of energy-related products including electricity, liquid, solid, and gaseous fuels, heat, chemicals, and other materials. Biomass energy is generated from wood products and byproducts, agricultural byproducts, ethanol, paper pellets, used railroad ties, landfill gas, digester gas, municipal solid waste, and methane (Global Insight, 2008; White & Walsh, 2008). Thus, biomass is often described as “waste-to-energy” fuel. In fact, one production method uses the waste of 10 cows per year to produce enough power to supply the needs of the average American home. Methane from waste landfills is also being used to power facilities such as industrial plant.

Recently, the biomass sector has faced some challenges to growth as it has been criticized for being renewable but not necessarily environmentally friendly. For example, wood-burning plants have been targeted for having potentially adverse environmental effects and for using non-sustainable resources (Ganci, 2011; Kaste, 2010). In response to such concerns, some states have adopted regulations that make it much more difficult for biomass facilities to be constructed (Environmental Leader, 2010). Biomass industry leaders also cite weak federal support as one contributor to slow acceptance by the general public (Voegele, 2011).

Hydrogen

Hydrogen is considered a clean energy carrier similar to electricity and can be made from a variety of methods including nuclear energy and renewable resources. The vast majority of hydrogen consumed in the U.S. is used for refining, treating metals, and processing foods (EIA, 2011b). One promising hydrogen-based energy system is hydrogen fuel cells. Interestingly, fuel cells have existed for more than a century, but because they require a constant supply of hydrogen, the limiting challenge has been how to create, store, and transport the hydrogen. Recognizing this challenge and the potential of hydrogen fuel cells as a source of clean and efficient fuel, the Hydrogen Fuel Initiative was announced in 2003 to promote hydrogen fuel cell vehicles from prototypes to in-use models.

Although several challenges confront the proliferation of hydrogen-based fuel cells, such as higher costs and lower availability of fueling centers (EIA, 2011b), sales of fuel cells have quadrupled between 2008-2010 (Department of Energy, 2011c), with a 25 percent increase from 2010 to 2011 alone (Fuel Cell Today, 2011). In addition, patents for new fuel cells increased 57 percent in 2010, which outpaced patents for other advanced energy technologies (Department of Energy, 2011c).

Workforce Implications

When considered collectively, the increased potential for growth in renewable sources of energy can be expected to impact employment and occupational expansion. This is generally attributed to the fact that renewable energy production is more labor-intensive than energy source production. A 2005 report estimated that significant investment in the renewable energy segment could result in the creation of more than 650,000 jobs by 2015 and more than 1.4 million jobs by 2025 (Wood, 2005). A more recent 2011 report by the International Labour Organization suggests that between 1.3 and 7.3 million new jobs related to renewable energy in the U.S. could be added by 2030 (Strietska-Ilina et al., 2011). For the period between 2003-2010, an analysis by the Brookings Institution reported that four of the five fastest growing green sectors were in renewable energy (see Table 5 below) (Muro et al., 2011).

Table 5. Brookings Institution Data for Renewable Energy Generation Sector

Renewable Energy Source	Percent Change 2003-2010	Direct Jobs 2010
Hydropower/Wave or Ocean Power	17.3	55,838
Wind	14.9	24,294
Solar Photovoltaic	10.7	24,152
Solar Thermal	18.4	5,379
Biofuels/Biomass	8.9	20,680
Geothermal	6.7	2,720

In terms of the greening of occupations, the 2009 report described this sector as having consequences for all three green occupational categories. First, green increased demand occupations related to renewable energy generation were expected (e.g., power distributors and dispatchers, power system operators, etc.). Second, green enhanced skills occupations were also expected. For instance, occupations such as power plant operators, electrical engineers, continuous mining machine operators, geological sample test technicians, and mechanical engineers fell within this occupational greening category in the 2009 report. Finally, because of the new technologies being used in this sector, several green new and emerging occupations were identified. Among these novel occupations were those associated with designing wind turbines or wind farms, assessing wind capacity, technician occupations for wind and geothermal operations, and the design or operation of biomass production facilities. Appendices A-C offer the full listing of occupations previously identified in each of the three occupational greening categories.

Since the 2009 report, demand has decreased for labor to fill jobs in green increased demand occupations in this sector. This reduction in demand for such “indirect” green economy occupations mirrors the broader economic slowdown for the labor market at large. For example, occupations related to energy-saving consumer products have seen recent employment losses, and those associated with power distribution are predicted to have little or no change in demand through 2018 (see Table 6 below for BLS projections). For green enhanced skill occupations, over 45 percent are expected to see employment growth, 33 percent to see employment decline, and the remainder to see no change in employment through 2018. The impact of green economy activities and technologies on the knowledge and skill requirements associated with these occupations remains (see Appendix D for examples of new green tasks). There is little evidence to suggest that any new technologies since the 2009 report have significantly permeated this sector to induce new additions to the list of green enhanced skill occupations.

Table 6. BLS Projections for Renewable Energy Generation Green Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Storage and Distribution Managers	Enhanced Skills	Average	Decline slowly or moderately
Civil Engineers	Enhanced Skills	Faster than average	Much faster than average
Electrical Engineers	Enhanced Skills	Slower than average	Little or no change
Mechanical Engineers	Enhanced Skills	Slower than average	Slower than average
Geological Sample Test Technicians	Enhanced Skills	Average	Little or no change
Nuclear Equipment Operation Technicians	Enhanced Skills	Average	Average
Sheet Metal Workers	Enhanced Skills	Average	Slower than average
Service Unit Operators, Oil, Gas, and Mining	Enhanced Skills	Decline slowly or moderately	Decline rapidly
Continuous Mining Machine Operators	Enhanced Skills	Slower than average	Decline slowly or moderately
Maintenance and Repair Workers, General	Enhanced Skills	Average	Average
Machinists	Enhanced Skills	Decline slowly or moderately	Decline slowly or moderately
Nuclear Power Reactor Operators	Enhanced Skills	Average	Faster than average
Power Plant Operators	Enhanced Skills	Slower than average	Little or no change
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	Enhanced Skills	Decline slowly or moderately	Average
Power Distributors and Dispatchers	Increased Demand	Decline slowly or moderately	Little or no change

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

Evidence supports the continued viability of the 20 green new and emerging occupations identified in the 2009 report (see Appendix C). For example, estimates from 2011 indicate continued demand and increased production of wind projects (American Wind Energy Association, 2011c). Installation-related occupations, such as solar thermal installers and technicians, are expected to increase by 22 percent by August 2012, and sales and distribution occupations, such as solar sales representatives and assessors, are expected to grow by 35 percent during the same time period (Solar Foundation, 2010). The hydropower industry continues to grow and has substantial yet untapped potential, which should increase demand for occupations related to hydroelectric plant operation (National Hydropower Association, 2010). Further, specialized training and certification programs continue to be offered for new and emerging wind occupations, such as wind energy engineers and wind turbine resource technicians (UMass Amherst, 2011; Wind Energy, 2011). Similarly, training and certification programs remain strong in the geothermal, hydropower, biomass, and solar segments (AASHE, 2011; NABCEP, 2011; Oregon.gov, 2011; Thompson Rivers, 2011; UC-San Diego, 2011; U.S. EDA, 2011). Finally, respondents for each of these green new and emerging occupations have been identified and surveyed since 2009 (see Appendix C).

Section II-2: Transportation

This green economy sector covers activities related to increasing efficiency and/or reducing the environmental impact of various modes of transportation, such as trucking, mass transit, freight rail, and water. Factors directing attention toward this sector include concerns about global warming, fuel shortages and rising costs, and a more general move toward sustainable transportation. The notion of sustainability in transportation centers on systems that meet transportation demands of people, businesses, and general society, while operating efficiently and limiting emissions, waste, consumption of non-renewable resources, land use, and noise production (Colleges of Ontario, 2001). A large proportion of the change occurring in this sector is attributed to increased production of renewable transportation fuels, such as ethanol and biodiesel, development and production of new vehicle engines, and re-engineered (eco-friendly) transportation systems (Global Insight, 2008). Several green technologies are playing a significant role in this sector. One example of such technology is auxiliary power units (APU) in transportation trucks, which reduce environmental impact from emissions as well as decreasing fuel costs (Gereffi, Dubay, & Lowe, 2008). Other examples of technologies important to green transportation include hybrid motors, intermodal transport, cold-ironing systems, and diesel particulate matter filters (Weinerth, 2010). The U.S. Department of Energy also provides numerous grants to support innovation in green transportation technology, recently offering $14.55 million along with matching private funds to total $29.3 million for alternative vehicle technologies (Department of Energy, 2008a).

Consumers worldwide are becoming increasingly interested in low-carbon vehicles due to a host of factors such as environmental awareness, regulations on vehicle production, and purchasing incentives (Strietska-Ilina et al., 2011). Reflecting this trend, U.S. sales of fuel cells have grown substantially in the past four years (Department of Energy, 2011c; Fuel Cell Today, 2011). For the period between 2003-2010, a Brookings Institution report noted the following employment trends related to the transportation sector (Muro et al., 2011).

Table 7. Brookings Institution Data for Transportation Sector

Transportation segment	Percent Change 2003-2010	Direct Jobs 2010
Fuel Cells	10.3	7,041
Electric Vehicle Technologies	6.3	15,711
Battery Technologies	1.4	16,129
Public Mass Transit	3.9	350,547

Workforce Implications

In terms of the greening of occupations, the 2009 report described this sector as having consequences for all three green occupational categories. First, several green increased demand occupations were expected in the 2009 report (e.g., railroad conductors, locomotive engineers, bus drivers). Second, many existing occupations were classified as green enhanced skills occupations with changes in the actual tasks and/or competencies that are required for occupational performance. For example, occupations such as automotive specialty technicians, transportation managers, and electronics engineers were identified as undergoing such changes. Finally, several green new and emerging occupations associated with green economy activities and technologies in this sector were identified. Among these novel occupations were fuel cell engineers and technicians, automotive engineers and technicians, and transportation engineers and planners. Appendix A offers the full listing of occupations previously identified in each of the three occupational greening categories.

Since the 2009 report, employment in green increased demand occupations in this sector has appeared to remain steady or to increase. For example, increases in mass public transit use as a response to reducing greenhouse gas emissions and air pollution are increasing the demand for bus drivers (New Mexico Green Jobs Cabinet, 2009). The continued adoption of hydrogen fuel cells should maintain demand for occupations involved in automobile production, design and engineering, as well as those that service transportation vehicles (Department of Energy, 2008b). In terms of future needs, all but one green increased demand occupation is forecast to see employment growth through

2018 (see Table 8 below for BLS projections). For green enhanced skill occupations, two thirds are expected to see employment growth through 2018. The impact of concerns over environmental and conservation issues in the transportation sector continues to require individuals with specialized knowledge and skills related to eco-friendly transportation assessment, planning, and logistics. Thus, the effects of green economy activities and technologies on the knowledge and skill requirements associated with these occupations are consistent with those described in the 2009 report (see Appendix D for examples of new green tasks). Further, research for the present report did not uncover any new technologies significantly in use that would induce additions to the list of green enhanced skill occupations for this sector.

Table 8. BLS Projections for Transportation Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Transportation Managers	Enhanced Skills	Average	Decline slowly or moderately
Aerospace Engineers	Enhanced Skills	Average	Average
Electronics Engineers, Except Computer	Enhanced Skills	Slower than average	Little or no change
Mechanical Engineers	Enhanced Skills	Slower than average	Slower than average
Shipping, Receiving, and Traffic Clerks	Enhanced Skills	Slower than average	Decline slowly or moderately
Automotive Specialty Technicians	Enhanced Skills	Faster than average	Slower than average
Bus and Truck Mechanics and Diesel Engine Specialists	Enhanced Skills	Average	Slower than average
Heavy and Tractor-Trailer Truck Drivers	Enhanced Skills	Average	Average

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Transportation Vehicle, Equipment and Systems Inspectors, Except Aviation	Enhanced Skills	Faster than average	Faster than average
Dispatchers, Except Police, Fire, and Ambulance	Increased Demand	Little or no change	Decline slowly or moderately
Rail-Track Laying and Maintenance Equipment Operators	Increased Demand	Slower than average	Faster than average
Bus Drivers, Transit and Intercity	Increased Demand	Average	Average
Locomotive Engineers	Increased Demand	Slower than average	Average
Railroad Conductors and Yardmasters	Increased Demand	Average	Average
Industrial Truck and Tractor Operators	Increased Demand	Little or no change	Slower than average

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

Evidence supports the continued viability of the 11 green new and emerging occupations identified in the 2009 report (see Appendix C). The demand for fuel cell use and technology appears to be on the rise; for example, the U.S. Department of Defense has recently been given a recommendation to add fuel cell powered vehicles (FCHEA, 2011). Numerous certification and degree-granting programs have been developed and continue to expand to train individuals for the new and emerging occupations in this sector. For instance, the Society of Automotive Engineers offers a number of green mobility courses and learning products and is involved in developing a green automotive center for technology transfer in Michigan (SAE, 2011). The Transportation Professional Certification Board and the American Planning Association offer certificate programs related to transportation planning. Several colleges are also offering or developing programs designed to train fuel cell technicians (Illinois WorkNet, 2011; Texas State Technical College, 2011). Finally, respondents for each of these green new and emerging occupations have been identified and surveyed since 2009 (see Appendix C).

Section II-3: Energy Efficiency

This sector of the green economy includes activities related to increasing energy efficiency and making energy demand response more effective. Because this sector is closely related to numerous industries, it often defies clear delineation. For instance, most financial investment in this sector is within segments of larger industries (e.g., vehicles, buildings, lighting, appliances) (Bedzek, 2007; Perry, 2008). Although a significant portion of this sector involves reducing waste of energy through systematic retrofitting and upgrading of residential and commercial buildings, (White & Walsh, 2008) those green activities are addressed in a following sector, "Green Construction."

A number of green technologies have been brought to bear in efforts to increase energy efficiency. For example, light-emitting diodes (LED) are a semiconductor technology whose application to general purpose lighting holds the promise of significant energy savings, with currently available products three to four times more efficient than incandescent bulbs (Gereffi, et al., 2008; Hansen, 2009). Another example of green technology in this sector is high performance window technology consisting of low-emissivity coated glass, gas fills, spacers, and improved frames. These high performance windows typically use materials such as fiberglass, vinyl, argon, and silica to reduce energy loss (Gereffi, et al., 2008). The promotion of "smart electrical grids" is also significantly impacting change within this sector. Smart grids employ a number of more specific technologies to meet several criteria set out by the U.S. Department of Energy including self-healing, attack resistance, higher quality power, accommodating generation and storage options, promoting energy markets, and increasing overall efficiency (NETL, 2007; Pike Research, 2011).

President Obama's recent "Better Building Initiative" is likely to promote private sector investment and efforts in the energy efficiency sector. This initiative sets goals for a 20 percent increase in energy efficiency for commercial buildings by 2020 (WhiteHouse.gov, 2011). With regard to future growth, a recent report by Goldman et al. (2010) estimated the national energy efficiency sector to

> …Increase to 220,000 person years of employment (PYE) (low-growth scenario) or 380,000 PYE (high-growth scenario) by 2020. This represents a two- to four-fold increase in the size of the [energy efficiency sector] from the 2008 baseline. Our estimates of future size of the [energy efficiency sector] workforce may be conservative because they do not explicitly account for the impacts of proposed federal climate change legislation with aggressive greenhouse gas reduction targets or a national energy efficiency portfolio standard, which could spur additional investment in energy efficiency and more job growth (Lawrence Berkley National Laboratory, 2010).

For the period between 2003-2010, an analysis of energy efficiency related segments by the Brookings Institution indicated mixed growth and decline (see Table 9 below) (Muro et al., 2011).

Table 9. Brookings Institution Data for Energy Efficiency Sector

Energy efficiency segment	Percent Change 2003-2010	Direct Jobs 2010
Smart Grid	8.6	15,987
HVAC and Building Control	3.3	73,600
Energy-Saving Building Materials	2.5	161,896
Lighting	-1.8	14,298
Energy-Saving Consumer Products	-2.9	19,210

Workforce Implications

The 2009 report described this sector as having experiencing all three categories of occupational greening. Green increased demand occupations in energy efficiency included electrical power line installers and repairers, stationary engineers and boiler operators, and boilermakers. In terms of green enhanced skill occupations, heating and air conditioning mechanics and installers, electrical engineers, and mechanical engineers were among those identified. Finally, three green new and emerging occupations were identified (i.e., energy auditors, energy engineers, and weatherization installers and technicians). Appendices A-C offer the full listing of occupations previously identified in each of the three occupational greening categories.

Since the 2009 report, employment demand for green increased demand occupations has appeared to remain steady or increase. For example, a recent survey of the energy industry reported that energy efficiency standards created approximately 340,000 jobs in 2010 alone and demand is expected to increase due to an aging workforce (Association of Energy Engineers, 2011a). All of the green increased demand occupations associated with this sector are forecasted for growth in employment through 2018 (see Table 10 below for BLS projections). For green enhanced skill occupations, 75 percent are forecasted to experience growth in employment through 2018. The knowledge and skill requirements spurred by green economy activities and technologies on these occupations appear to remain (see Appendix D for examples of new green tasks). Further, there are no new technologies or processes that seem to have impacted work in this sector enough to warrant new additions to the list of green enhanced skill occupations since the 2009 report.

Table 10. BLS Projections for Energy Efficiency Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
General and Operations Managers	Enhanced Skills	Little or no change	Little or no change
Training and Development Specialists	Enhanced Skills	Faster than average	Much faster than average
Financial Analysts	Enhanced Skills	Much faster than average	Much faster than average
Electrical Engineers	Enhanced Skills	Slower than average	Little or no change
Mechanical Engineers	Enhanced Skills	Slower than average	Slower than average
Heating and Air Conditioning Mechanics and Installers	Enhanced Skills	Average	Much faster than average
Maintenance and Repair Workers, General	Enhanced Skills	Average	Average
Transportation Vehicle, Equipment and Systems Inspectors, Except Aviation	Enhanced Skills	Faster than average	Faster than average
Boilermakers	Increased Demand	Faster than average	Faster than average
Insulation Workers, Floor, Ceiling, and Wall	Increased Demand	Average	Faster than average
Refrigeration Mechanics and Installers	Increased Demand	Average	Much faster than average
Electrical Power-Line Installers and Repairers	Increased Demand	Average	Slower than average
Stationary Engineers and Boiler Operators	Increased Demand	Slower than average	Slower than average

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

Current evidence supports the continued viability of the three green new and emerging occupations identified in the 2009 report (see Appendix C). For example, employment demand appears strong for occupations related to weatherization (Illinois WorkNet, 2011b). In addition, training and certification programs continue to exist and expand for energy engineers, weatherization, and energy efficiency related occupations (Association of Energy Engineers, 2011b; 2011c; Building Performance Institute, 2011; Pennsylvania Department of Labor and Industry, 2009). Finally, evidence seems to support the viability of an additional new and emerging occupation to be considered in this sector. This candidate occupation pertains to individuals working as testing, adjusting and balancing (TAB) technicians. This work entails fine-tuning HVAC systems so that they work at maximum efficiency to decrease energy costs and adverse environmental impacts. There is evidence for increased demand for this type of work and there are current offerings in both certification and apprenticeship programs (Massachusetts Green Energy Careers, 2011; National Environmental Balancing Bureau, 2011). Finally, respondents for each of these green new and emerging occupations have been identified and surveyed since 2009 (see Appendix C).

Section II-4: Green Construction

This sector covers activities related to designing and constructing new green buildings, retrofitting residential and commercial buildings, and installing other green construction technology. Roughly two thirds of this sector's activities are undertaken by firms that are engaged in design or construction, with the remainder involved with the production and sales of green construction materials (Global Insight, 2008; Green Jobs Guidebook, 2008). The broad goals of increasing energy efficiency in residential and commercial structures are likely to foster growth in this green economy sector. This "green construction market" has been defined as encompassing structures

> "…built to LEED standards, an equivalent green building certification program, or one that incorporates numerous green building elements across five category areas: energy efficiency, water efficiency, resource efficiency, responsible site management and improved indoor air quality" (McGraw-Hill, 2008).

Government-sponsored initiatives have been central to promoting green construction. For example, efforts by the U.S. Environmental Protection Agency's Energy Star® buildings program and the U.S. Green Building Council's LEED™ rating system develop systems by which the energy and environmental performance of office buildings can be measured and compared to national norms, and LEED ratings for residential buildings have been introduced (Conway, 2005; Global Insight, 2008). Several green technologies are also influencing green construction activities. Many fall into "mechanical technologies" and include innovations such as on-site electricity generating equipment and blackwater recycling systems (Dierdorff et al., 2005). Other new

technologies include insulation materials, cement alternatives, modular housing, and architectural designs for thermal management (Weinerth, 2010).

Some analysts have argued that despite the overall downturn in construction over the last few years, green construction projects, such as those related to retrofitting for energy efficiency, have remained a bright spot for growth (Pike Research, 2011). A Booz Allen Hamilton study released by U.S. Green Building Council in 2009 forecasts that this sector will support or create 7.9 million jobs by 2013, contributing $554 billion to the U.S. gross domestic product (USGBC, 2010). A recent Brookings Institution report noted that two segments of green construction (green architecture and construction services and green building materials) showed positive growth between 2003 and 2010 (Muro et al., 2011). Finally, President Obama's recent "Better Building Initiative" is intended to spark private sector investment and efforts in this green sector, as it sets a goal for commercial buildings to be 20 percent more energy efficient by 2020 and offers a series of incentives to upgrade offices, stores, schools and other municipal buildings, universities, hospitals, and so forth (WhiteHouse.gov, 2011).

Workforce Implications

The 2009 report described this sector as experiencing all three categories of occupational greening, although the majority of impact was in terms of increased employment demand and new skill or task requirements. For example, green increased demand occupations in green construction included architectural drafters, electricians, construction carpenters, structural iron and steel workers, and cement masons and concrete finishers. With regard to green enhanced skill occupations, this sector contained occupations such as architects, civil engineers, construction managers, sheet metal workers, and plumbers. Only a single green new and emerging occupation associated with green construction (also related to energy efficiency) was identified in the 2009 report – energy engineer. Appendices A-C offer the full listing of occupations previously identified in each of the three occupational greening categories.

Since the 2009 report, employment demand for green increased demand occupations in this sector has been stronger as compared to the state of the overall construction industry (Redman, 2010). The majority (approximately 75 percent) of green increased demand occupations associated with green construction are forecasted for growth in employment through 2018 (see Table 11 below for BLS projections). Of the 19 green enhanced skill occupations, nearly 90% are forecasted to show growth in employment demand through 2018. Research for the present report did not find significant evidence of new green construction technology or activities that might warrant further additions to the list generated in the 2009 report. Appendix D provides examples of new green tasks associated with green enhanced skill occupations. As mentioned in the previous section on the energy efficiency sector, evidence of employment demand and certification programs continues to support the viability of energy engineers as a green new and emerging occupation (American Wind Energy

Association, 2011d; 2011e; iSeek.org, 2011) In addition, data have been collected for this occupation since 2009 (see Appendix C).

Table 11. BLS Projections for Green Construction Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Construction Managers	Enhanced Skills	Faster than average	Faster than average
Training and Development Specialists	Enhanced Skills	Faster than average	Much faster than average
Financial Analysts	Enhanced Skills	Much faster than average	Much faster than average
Architects, Except Landscape and Naval	Enhanced Skills	Faster than average	Faster than average
Landscape Architects	Enhanced Skills	Faster than average	Much faster than average
Civil Engineers	Enhanced Skills	Faster than average	Much faster than average
Electrical Engineers	Enhanced Skills	Slower than average	Little or no change
Mechanical Engineers	Enhanced Skills	Slower than average	Slower than average
Urban and Regional Planners	Enhanced Skills	Faster than average	Faster than average
Construction Laborers	Enhanced Skills	Average	Much faster than average
Pipe Fitters and Steamfitters	Enhanced Skills	Average	Faster than average
Plumbers	Enhanced Skills	Average	Faster than average
Roofers	Enhanced Skills	Faster than average	Slower than average
Sheet Metal Workers	Enhanced Skills	Average	Slower than average
Construction and Building Inspectors	Enhanced Skills	Faster than average	Faster than average
Hazardous Materials Removal Workers	Enhanced Skills	Average	Faster than average

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Heating and Air Conditioning Mechanics and Installers	Enhanced Skills	Average	Much faster than average
Maintenance and Repair Workers, General	Enhanced Skills	Average	Average
Power Plant Operators	Enhanced Skills	Slower than average	Little or no change
Architectural Drafters	Increased Demand	Slower than average	Average
Boilermakers	Increased Demand	Faster than average	Faster than average
Construction Carpenters	Increased Demand	Average	Average
Rough Carpenters	Increased Demand	Average	Average
Cement Masons and Concrete Finishers	Increased Demand	Average	Average
Operating Engineers and Other Construction Equipment Operators	Increased Demand	Average	Average
Electricians	Increased Demand	Average	Average
Insulation Workers, Floor, Ceiling, and Wall	Increased Demand	Average	Faster than average
Structural Iron and Steel Workers	Increased Demand	Slower than average	Average
Helpers--Carpenters	Increased Demand	Average	Much faster than average
Refrigeration Mechanics and Installers	Increased Demand	Average	Much faster than average

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Helpers--Installation, Maintenance, and Repair Workers	Increased Demand	Average	Average
Structural Metal Fabricators and Fitters	Increased Demand	Little or no change	Little or no change
Welders, Cutters, and Welder Fitters	Increased Demand	Slower than average	Little or no change
Solderers and Brazers	Increased Demand	Slower than average	Little or no change
Industrial Truck and Tractor Operators	Increased Demand	Little or no change	Slower than average
Laborers and Freight, Stock, and Material Movers, Hand	Increased Demand	Little or no change	Little or no change

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

Section II-5: Energy Trading

This green economy sector involves various financial services related to buying and selling energy as an economic commodity, as well as carbon trading projects (Green Jobs Guidebook, 2008) At least part of the growth of this sector has stemmed from industry deregulation. Such deregulation has led to the increase of trading electricity as a commodity, also known as “power marketing” or “energy marketing”. This business model has been directly adopted by entities commonly referred to as “non-utility generators,” typically industrial plants that generate their own power and sell it to utilities or other industrial plants. For example, of the more than 3000 electric utilities in the U.S., over half do not have generating capacity but rather purchase electricity from other utilities. Thus, many electric power plants are seen as commodity-producing investments. In addition to energy marketing, there is a simultaneous push to reduce costs through power conservation. The other significant portion of this sector is devoted to emission trading, frequently focused on carbon trading. In short, the carbon trading market has developed from caps or limits on the amount of carbon dioxide that can be emitted by a particular entity. Companies or other groups are granted emission permits and must hold an equivalent number of credits that represent the right to emit a specific amount of carbon dioxide. Because of the limiting caps, companies that need to increase their emission allowance need to purchase (trade) credits from other firms.

Some estimates have shown overall growth in this sector; however, much of this information comes from international and European trading volumes (Prospex Research, 2010; PRWEB, 2011). In the U.S. several significant challenges have arisen in the past three years that have impacted sector progress. For example, allegations of price-fixing have been made, which increase the likelihood of heavier federal regulation and slowed growth (Dizikes, 2011). Not constrained to the U.S., governmental agencies in other countries, such as the UK, have also issued consumer alerts about carbon credit trading scams (Levene, 2011; Reyes, 2010). Finally, court rulings in states such as California have substantially slowed and delayed carbon trading (Bardelline, 2011; Romm, 2011). These conditions have led some analysts to declare the U.S. carbon trading market as unviable (Boyle, 2010; Farzad, 2010).

Workforce Implications

Energy marketing, power conservation, and emissions trading have implications for employment and new occupational growth in areas such as auditing, market analysis, brokerage work, and so forth. For example, occupations related to both financial analysis and emissions analysis are required for carbon trading. Research for the 2009 report, however, found this sector to experience minimal occupational greening overall but did identify consequences for three new and emerging occupations relative to the O*NET-SOC taxonomy. In particular, two of these occupations were derived from the broader financial services industry, but deemed relevant to energy trading (investment underwriters and securities and commodities traders). The third new and emerging occupation, energy brokers, was specific to energy trading. Appendix C provides a description of these three occupations.

Since 2009 employment in the broader financial services industry has slowed considerably in conjunction with the global economic slowdown. Despite this deceleration, there are some projections of increased employment for investment underwriters and securities and commodities traders through 2018. Investment in green buildings continues to receive attention and initial underwriting standards have been developed to govern such investment activity (Capital Markets, 2008). The instability and uncertainty in the carbon trading market makes it currently unclear whether or not energy brokers will experience employment growth or decline (Farzad, 2010). However, some positive evidence may be seen in the recent formation of the Energy Brokers Association (see www.energybrokersassoc.org).

Section II-6: Energy and Carbon Capture and Storage

This sector covers green economy activities related to capturing and storing energy and/or carbon emissions (Green Jobs Guidebook, 2008; Perry, 2008). The primary force in this sector is the increase in coal-based power plants using integrated gasification combined cycle (IGCC) techniques. The World Coal Institute describes the

IGCC technique as follows: An alternative to achieving efficiency improvements in conventional pulverized coalfired power stations is through the use of gasification technology. IGCC plants use a gasifier to convert coal (or other carbon-based materials) to syngas, which drives a combined cycle turbine. Coal is combined with oxygen and steam in the gasifier to produce the syngas, which is mainly H2 and carbon monoxide (CO). The gas is then cleaned to remove impurities, such as sulphur, and the syngas is used in a gas turbine to produce electricity. Waste heat from the gas turbine is recovered to create steam, which drives a steam turbine, producing more electricity. The result is a combined cycle system (World Coal Institute, 2011).

The benefit of IGCC plants is that they use less water and emit fewer airborne sulfur oxides, nitrogen oxides, particulates, and mercury than conventional pulverized coal plants. IGCC plants still produce carbon dioxide but this greenhouse gas can be concentrated and removed prior to combustion (i.e., “carbon capture and storage” [CCS]). Although IGCC technology is currently being implemented, most experts agree that CCS is farther behind in terms of development and use (Francis et al., 2007). Several obstacles to CCS have contributed to this slowed progress. For example, current CCS approaches that rely on absorption techniques are not very cost-effective and thus could increase the cost of electricity by 60% (Department of Energy, 2011d; World Energy Source, 2009). A sluggish economy has also contributed to postponement or cancellation of several large-scale CCS projects both domestically and worldwide (Wells & Elgin, 2011; World Nuclear Assocation, 2011).

The U.S. Department of Energy cites several new technologies for CCS aimed at improving cost-effectiveness. For example, improvements in carbon dioxide separation and capture technologies using new materials (e.g., physical and chemical absorbents, carbon fiber molecular sieves, polymeric membranes) and oxygen-enhanced combustion approaches, developing retrofittable reduction and capture options, and integrating carbon dioxide capture with advanced power cycles and with environmental control technologies for pollutants (Department of Energy, 2011d). However, these new technologies are still in the research and development phase.

Workforce Implications

The 2009 report noted that technologies related to carbon capture and storage could generate increased demand for knowledge and skills needed for processes such as geologic or terrestrial carbon sequestration (Green Jobs Guidebook, 2008). However, this sector overall was not expected to experience significant greening in the immediate future. This appears to remain the current state of this sector as well, with much of the activity centering on research and development of technology rather than implementation and use (Wesoff, 2011). The 2009 report identified one green enhanced skill occupation related to this sector (power plant operators). Employment estimates show little or no change for this occupation through 2018. Yet, there are some promising estimates such as those provided in a recent Brookings Institution report that

found 13 percent job growth in this sector between 2003 and 2010; although the number of jobs in 2010 was rather small (391 jobs) (Muro et al., 2011) In addition, the North American Carbon Capture and Storage Association continues to lobby for research and development in this area in order to create and deploy commercially viable technology (NCCSA, 2011).

Section II-7: Research, Design, and Consulting Services

This sector encompasses “indirect jobs” to the green economy and includes activities such as energy consulting or research and other related business services. Although not directly related to green technology, these types of occupations have accounted for a significant portion of employment growth in the green economy. For example, it has been estimated that jobs in this sector have grown by 52% from 1990 to 2008 as compared to a 38% increase in direct jobs during the same time period (Global Insight, 2008) More recent estimates of growth since 2009 are difficult to obtain, as the indirect nature of the occupations in this sector means they fall into other more traditional industries. Thus, occupations in this sector have typically not been encompassed in the specific analyses conducted by more recent green economy focused research.

Workforce Implications

In the 2009 report, occupations in all three greening categories were identified in this sector. For example, it was expected that this sector would include green increased demand and green enhanced skills occupation through “indirect jobs” or occupations such as financial analysts, sales representatives, geoscientists, engineering managers, marketing managers, and public relations specialists. A total of 11 green increased demand occupations and 23 green enhanced skill occupations were designated. A large number of green new and emerging occupations were linked to this sector (37 in total), however, all but one occupation were indirect and derived from prior research on other industries (e.g., biotechnology). The lone direct green new and emerging occupation for this sector was green marketers. Appendices A-C offer the full listing of occupations previously identified in each of the three occupational greening categories.

Projections for employment change show 80 percent of the green increased demand occupations and 73 percent of green enhanced skill occupations predicted to have employment growth through 2018 (see Table 12 below for BLS projections).

Table 12. BLS Projections for Research, Design, and Consulting Services Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Marketing Managers	Enhanced Skills	Faster than average	Average
Architectural and Engineering Managers	Enhanced Skills	Average	Slower than average
Wholesale and Retail Buyers, Except Farm Products	Enhanced Skills	Little or no change	Little or no change
Training and Development Specialists	Enhanced Skills	Faster than average	Much faster than average
Financial Analysts	Enhanced Skills	Much faster than average	Much faster than average
Personal Financial Advisors	Enhanced Skills	Much faster than average	Much faster than average
Architects, Except Landscape and Naval	Enhanced Skills	Faster than average	Faster than average
Aerospace Engineers	Enhanced Skills	Average	Average
Civil Engineers	Enhanced Skills	Faster than average	Much faster than average
Electrical Engineers	Enhanced Skills	Slower than average	Little or no change
Electronics Engineers, Except Computer	Enhanced Skills	Slower than average	Little or no change
Mechanical Engineers	Enhanced Skills	Slower than average	Slower than average
Nuclear Engineers	Enhanced Skills	Average	Average
Atmospheric and Space Scientists	Enhanced Skills	Average	Faster than average
Geoscientists, Except Hydrologists and Geographers	Enhanced Skills	Much faster than average	Faster than average
Urban and Regional Planners	Enhanced Skills	Faster than average	Faster than average
Geophysical Data Technicians	Enhanced Skills	Average	Little or no change

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Geological Sample Test Technicians	Enhanced Skills	Average	Little or no change
Arbitrators, Mediators, and Conciliators	Enhanced Skills	Average	Faster than average
Reporters and Correspondents	Enhanced Skills	Little or no change	Decline slowly or moderately
Public Relations Specialists	Enhanced Skills	Faster than average	Much faster than average
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	Enhanced Skills	Average	Average
Software Developers, Systems Software	Increased Demand	Much faster than average	Much faster than average
Chemical Engineers	Increased Demand	Average	Little or no change
Industrial Safety and Health Engineers	Increased Demand	Average	Average
Industrial Engineers	Increased Demand	Faster than average	Faster than average
Chemists	Increased Demand	Average	Little or no change
Materials Scientists	Increased Demand	Average	Average
Hydrologists	Increased Demand	Much faster than average	Faster than average
Commercial and Industrial Designers	Increased Demand	Average	Average
Occupational Health and Safety Specialists	Increased Demand	Average	Average
Customer Service Representatives	Increased Demand	Much faster than average	Faster than average
Electrical and Electronics Repairers, Commercial and Industrial Equipment	Increased Demand	Average	Slower than average

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

As for the new and emerging occupations linked to this sector, the majority of occupations are engineering-related. Evidence is supportive of the sustainability of these occupations. For example, green engineering jobs (e.g., smart grid engineers, thermal engineers, and energy engineers) have been listed among the most promising, high growth areas of engineering employment (Green Careers Guide, 2011). In addition, research in this area is represented by a dedicated journal – the *Journal of Green Engineering*. With respect to green marketers, recent evidence appears to support the continued viability of this occupation, which includes professional associations and specialized training programs (DMC, 2008; GMC, 2011) Finally, respondents for each of these green new and emerging occupations have been identified and surveyed since 2009 (see Appendix C).

Section II-8: Environmental Protection

This sector covers activities related to environmental remediation, climate change adaptation, and ensuring or enhancing air quality. Environmental remediation entails the restoration of a contaminated site to a condition that is not a threat to human or animal health. Numerous technologies are used for remediation efforts including ion exchange, soil washing, chemical precipitation, oxidation, electrolytic treatment, and biological treatments with plants, fungi, and bacteria. Climate change adaptations are “actions taken to help communities and ecosystems moderate, cope with, or take advantage of actual or expected changes in climate conditions” (USAID, 2007). Efforts to enhance air quality generally encompass activities related to minimizing or eliminating various pollutants. According to the U.S. Department of Transportation, these pollutants come from many sources: stationary sources (e.g., factories and power plants), dispersed sources (e.g., dry cleaners and painting operations), mobile sources (e.g., cars, buses, planes, trucks, and trains), and, natural sources (e.g., windblown dust and volcanic eruptions) (Department of Transportation, 2008).

Several new technologies are being implemented in this sector. For example, cattails have been successfully used to reduce water pollutants such as phosphorous (Casey, 2009a). In terms of contaminated soil remediation, rather than digging and removing the soil to landfills, new “bioremediation” processes have been employed, such as those using the cleaning power of bacteria (Casey, 2009b). The overall sluggish economy over the past 3 years has seemed to slow down growth in this sector. To help facilitate this sector, the U.S. EPA awarded over $2.2 million as part of their Small Business Innovation Research program in 2011(Green Progress, 2011). In terms of employment in this sector, several state-level reports have shown small gains (Illinois Department of Employment Security, 2011; Tennessee Department of Labor and Workforce Development, 2011; Washington State Employment Security Department, 2010). A recent report by the Brookings Institution also indicated growth for segments related environmental protection (see Table 13 below) (Muro et al., 2011).

Table 13. Brookings Institution Data for Environment Protection Sector

Environmental protection segment	Percent Change 2003-2010	Direct Jobs 2010
Professional Environmental Services	6.8	141,046
Remediation	4.7	56,241
Air and Water Purification Technologies	4.7	24,930
Pollution Reduction	-1.4	9,986

Workforce Implications

In the 2009 report, this sector was expected to promote demand for nine existing occupations. Among these green increased demand occupations were occupations such as environmental scientists, natural sciences managers, forest and conservation workers, and hydrologists. Several occupations in this sector were also described as likely experience changes in the tasks and/or competencies required for occupational performance. Among the 14 green enhanced skill occupations identified in the 2009 report were occupations such as environmental engineers, hazardous materials removal workers, environmental engineering technicians, atmospheric and space scientists, and soil and water conservationists. Finally, seven green new and emerging occupations were identified in this sector, including brownfield redevelopment specialists and site managers, climate change analysts, environmental economists, environmental restoration planners, and industrial ecologists. Appendix A offers the full listing of occupations previously identified in each of the three occupational greening categories.

Since 2009, evidence supports the continued and consistent impact of this sector on employment demand and occupational requirements. For example, the vast majority (89 percent) of the nine green increased demand occupations are predicted to show employment growth through 2018 (see Table 14 below for BLS projections). Similarly, of the 14 green enhanced skill occupations, all but one (reporters and correspondents) is forecasted for employment growth through 2018. Research for the present report also did not find significant evidence of new technology or activities pertaining to environmental protection that would warrant additions to the list generated in the 2009 report. Appendix D provides example of new green tasks associated with green enhanced skill occupations.

Table 14. BLS Projections for Environment Protection Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Construction Managers	Enhanced Skills	Faster than average	Faster than average
Architectural and Engineering Managers	Enhanced Skills	Average	Slower than average
Landscape Architects	Enhanced Skills	Faster than average	Much faster than average
Environmental Engineers	Enhanced Skills	Much faster than average	Much faster than average
Environmental Engineering Technicians	Enhanced Skills	Much faster than average	Much faster than average
Soil and Plant Scientists	Enhanced Skills	Average	Faster than average
Soil and Water Conservationists	Enhanced Skills	Slower than average	Average
Atmospheric and Space Scientists	Enhanced Skills	Average	Faster than average
Geoscientists, Except Hydrologists and Geographers	Enhanced Skills	Much faster than average	Faster than average
Environmental Science and Protection Technicians, Including Health	Enhanced Skills	Much faster than average	Much faster than average
Reporters and Correspondents	Enhanced Skills	Little or no change	Decline slowly or moderately
Public Relations Specialists	Enhanced Skills	Faster than average	Much faster than average
Hazardous Materials Removal Workers	Enhanced Skills	Average	Faster than average
Maintenance and Repair Workers, General	Enhanced Skills	Average	Average
Natural Sciences Managers	Increased Demand	Average	Faster than average
Zoologists and Wildlife Biologists	Increased Demand	Average	Average

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Environmental Scientists and Specialists, Including Health	Increased Demand	Much faster than average	Much faster than average
Hydrologists	Increased Demand	Much faster than average	Faster than average
Forest and Conservation Technicians	Increased Demand	Little or no change	Average
Farm and Home Management Advisors	Increased Demand	Slower than average	Little or no change
Fish and Game Wardens	Increased Demand	Little or no change	Average
First-Line Supervisors of Logging Workers	Increased Demand	Little or no change	Average
Forest and Conservation Workers	Increased Demand	Slower than average	Average

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

Evidence continues to support the viability of the seven green new and emerging occupations. For instance, job opportunities in water-related resource management have grown substantially in recent years (Cyber-Sierra, 2011). The EPA's Brownfields and Land Revitalization program continues to actively promote a variety of initiatives (EPA, 2011). In addition, professional associations and training and certification programs related to water resource engineering, environmental economics, and brownfield reclamation continue to exist and expand (e.g., Association of Environmental and Resource Economists and the American Academy of Water Resources Engineers). Finally, respondents for each of these green new and emerging occupations have been identified and surveyed since 2009 (see Appendix C).

Section II-9: Agriculture and Forestry

This sector covers activities related to the use of natural pesticides, efficient land management or farming, and aquaculture (Global Insight, 2008; Perry, 2008). Broadly speaking, many of this sector's activities are often referred to as "sustainable agriculture" (NCAT, 2011). Related to the use of natural pesticides is the increase in consumer demand for certified organically-farmed foods. According to the European Commission, organic farming is a form of agriculture that maintains soil productivity and

controls pests by excluding or limiting the use of synthetic fertilizers and pesticides, plant growth regulators, feed additives, and genetically modified organisms (European Commission, 2011) The increase in consumer demand has contributed to the growth of organic farming and the food products from these farms. For example, from 2001 to 2006 the demand for organic products rose 10% to a total $40 billion in sales (Willer & Youssefi, 2007). Within the past seven years, industry analysts have reported 20 percent growth each year and are forecasting continued, but slower, future growth (Agriculture Marketing Resource Center, 2011).

Efficient land use and management has been facilitated by the application of geospatial technology. For example, “precision farming” uses geospatial data and information systems to plan, manage, and evaluate farming processes. This technology uses geospatial information to plan specific agricultural methods to be used in localized areas of an individual farm, with the intention of maximizing crop yields and minimizing environmental impact. Other technology includes measurement tools to more accurately assess levels of soil nutrients for more efficient application of fertilizers, as well as hydroponic and aeroponic farming systems (Wesoff, 2010; Green Technology Investments, 2011). Related to mitigating environmental impact of agriculture, it has been estimated that agricultural activities are responsible for nearly 30% of total U.S. methane emissions (Gereffi, et al., 2008). To help lessen this impact, green technologies such as “super soil systems” have been developed and implemented. Super soil entails on-farm waste treatment whereby the wastes are reduced to solids and treated liquid effluent streams. These solids are then composted off-site to be cured and used as organic fertilizers and soil enhancements. In addition, a byproduct of these systems is methane gas, which can be recycled using “biogas digesters” and then used as fuel for generating electricity (Gereffi, et al., 2008).

In terms of recent growth and forecasted growth projections in this green sector, increased pressure toward reducing greenhouse gas emissions, of which agricultural activity is a significant contributor, is likely to promote growth in this green sector. For example, there is some evidence that farming practices designed to reduce emissions not only achieve reductions in carbon emissions, but also promote farm profitability (OECD, 2010; Wreford, Moran, & Adger, 2010) The broader agriculture, forestry, and fishing industry sector is projected to experience little or no change in employment through 2018, which is a contrast to many years of employment declines. A recent report by Oregon Employment Department found jobs related to organic farming to be slowly, but steadily growing (Krumenauer & Johnson, 2011). A broader analysis by the Brookings Institution indicated growth for some segments related to agriculture and forestry (see Table 15 below) (Muro et al., 2011).

Table 15. Brookings Institution Data for Agriculture and Forestry Sector

Agriculture and forestry segment	Percent Change 2003-	Direct Jobs 2010
Conservation	7.2	314,983
Organic Food and Farming	1.8	129,956
Sustainable Forestry Products	-1.0	61,054

Workforce Implications

The 2009 report described this sector as having at least some consequences for all three categories of occupations. For instance, green increased demand occupations were expected, and included agricultural inspectors, supervisors of crop and horticulture workers, and buyers and purchasing agents of farm products. Green enhanced skills occupations identified in the 2009 report included farmers and ranchers, landscape architects, agricultural technicians, and general and operations managers. Precision agriculture technician was the only occupation to be identified as a green new and emerging occupation in this sector. Appendices A-C provide descriptions of occupations from all three occupational greening categories.

In terms of employment projections for green increased demand occupations, BLS forecasts both agricultural inspectors and supervisors of crop and horticulture workers to show employment growth through 2018, whereas buyers and purchasing agents of farm products is predicted to remain unchanged (see Table 16 below for BLS projections). Green enhanced skill occupations have mixed employment projections. Landscape architects and agricultural technicians are predicted to display growth through 2018, whereas general and operations managers and farmers and ranchers are expected to show decline or remain unchanged. Appendix D shows examples of new tasks associated with green enhanced skill occupations. No new technologies or practices were found to suggest new additions to the 2009 listing of green enhanced skill occupations.

Table 16. BLS Projections for Agriculture and Forestry Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
General and Operations Managers	Enhanced Skills	Little or no change	Little or no change
Farm and Ranch Managers	Enhanced Skills	Decline slowly or moderately	Decline slowly or moderately
Landscape Architects	Enhanced Skills	Faster than average	Much faster than average

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Agricultural Technicians	Enhanced Skills	Average	Average
Buyers and Purchasing Agents, Farm Products	Increased Demand	Decline slowly or moderately	Little or no change
First-Line Supervisors of Agricultural Crop and Horticultural Workers	Increased Demand	Little or no change	Average
Agricultural Inspectors	Increased Demand	Little or no change	Average

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

Evidence continues to support the viability of precision agriculture technicians as a green new and emerging occupation. For example, recent reports in Illinois and Minnesota report increased demand for this occupation (Illinois WorkNet, 2011c; iSeek.org, 2011). In addition, concerted efforts toward curriculum development and degree programs have been evident (ATEEC, 2011; Lansing Community College, 2011). Data collection efforts for this occupation have also been successful (see Appendix C).

Finally, there is mounting evidence to suggest that an organic farmers occupation may be as strong candidate as a new occupation in this sector. For instance, the Organic Farming Research Association reports that there are currently 14,500 organic farmers in the U.S. and predicts that 42,000 organic farmers will be needed by 2015 to meet expected demands for organic food products (OFRF, 2011). There are also several organic farming educational or training programs at the university level, such as at Michigan State University (see www.msuorganicfarm.org/organic-farmer-training-program).

Section II-10: Manufacturing

This sector covers activities related to industrial manufacturing of green technology as well as energy efficient manufacturing processes. There are two broad facets of green economy activities in the manufacturing sector. The first is the manufacturing of “green” materials that are required by other sectors of the green economy (e.g., renewable energy, construction). The second is the application of techniques and/or technologies to the manufacturing process. This latter category is highly related to

previous sectors, such as energy efficiency and carbon capture. According to the Center for Green Manufacturing at the University of Alabama, the purpose of green manufacturing is “to prevent pollution and save energy through the discovery and development of new knowledge that reduces and/or eliminates the use or generation of hazardous substances in the design, manufacture, and application of chemical products or processes.”

Growth in this green sector has been marginal over the past few years, which mirrors the trajectory of the broader manufacturing sector that has been stagnant. Yet, some states have seen growth in green manufacturing in recent years (e.g., Michigan) (Environmental Law, 2011a; 2011b). Challenges associated with job growth in sector include uncertainty in federal energy policy, reduced overall power demand, absence of fair trade policies for international trade, and the cost effectiveness of outsourcing to countries such as China (Runyon, 2010; Tankersly, 2010). With regard to employment related to this sector, a recent report shows overall shrinkage in jobs associated with most green product segments (see Table 17 below) (Muro et al., 2011). This is in part due to declines in new construction that have led to reduced demand for green appliances and fixtures, for example.

Table 17. Brookings Institution Data for Manufacturing Sector

Manufacturing segment	Percent Change 2003-2010	Direct Jobs 2010
Energy-saving Building Materials	2.5	161,896
Recycled-Content Products	0.8	59,712
Green Consumer Products	0.0	77,264
Energy-saving Consumer Products	-2.9	19,210
Appliances	-3.1	36,608
Green Chemical Products	-3.4	22,622
Water Efficient Products	-7.3	13,066

Workforce Implications

Occupations across all three occupational greening categories were identified in the 2009 report. A total of 28 green increased demand occupations were designated. Examples of these occupations included a host of existing manufacturing occupations: drilling and boring machine tools setters, operators and tenders; industrial machinery mechanics; millwrights; solderers and brazers; and, team assemblers. Twelve green enhanced skills occupations were also identified and included occupations such as industrial engineering technicians, electrical engineering technicians, machinists, and occupational health and safety technicians. Finally, 23 new and emerging occupations were identified as being associated with activities in the green manufacturing sector.

Some examples of these new and emerging occupations included biochemical engineers, logistics engineers, microsystems engineers, nanotechnology engineering technicians, and photonics technicians. Appendices A-C provide a full listing of manufacturing sector occupations across all three occupational greening categories.

Projections of employment demand for green increased demand occupations are mixed across the 28 occupations identified in 2009. For example, 35 percent of the occupations are expected to grow, 28 percent are expected to decline, and 35 percent are expected to remain unchanged through 2018 (see Table 18 below for BLS projections). With respect to the 12 green enhanced skill occupations, about 58 percent are expected to see employment growth, 33 percent to see employment decline, and 8 percent to see no change in employment through 2018. The impact of green economy activities and technologies on the knowledge and skill requirements associated with these occupations remains (see Appendix D for examples of new green tasks). There is little evidence to suggest that any new technologies since the 2009 report have significantly permeated this sector to induce new additions to the list of green enhanced skill occupations.

Table 18. BLS Projections for Manufacturing Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Electrical Engineering Technicians	Enhanced Skills	Slower than average	Little or no change
Electro-Mechanical Technicians	Enhanced Skills	Slower than average	Decline slowly or moderately
Industrial Engineering Technicians	Enhanced Skills	Average	Average
Occupational Health and Safety Technicians	Enhanced Skills	Faster than average	Faster than average
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	Enhanced Skills	Average	Average
Shipping, Receiving, and Traffic Clerks	Enhanced Skills	Slower than average	Decline slowly or moderately
Sheet Metal Workers	Enhanced Skills	Average	Slower than average
Maintenance and Repair Workers, General	Enhanced Skills	Average	Average

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Aircraft Structure, Surfaces, Rigging, and Systems Assemblers	Enhanced Skills	Average	Average
Machinists	Enhanced Skills	Decline slowly or moderately	Decline slowly or moderately
Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	Enhanced Skills	Decline slowly or moderately	Average
Inspectors, Testers, Sorters, Samplers, and Weighers	Enhanced Skills	Decline slowly or moderately	Decline slowly or moderately
Industrial Production Managers	Increased Demand	Decline slowly or moderately	Decline slowly or moderately
Industrial Safety and Health Engineers	Increased Demand	Average	Average
Electronics Engineering Technicians	Increased Demand	Slower than average	Little or no change
Chemists	Increased Demand	Average	Little or no change
Materials Scientists	Increased Demand	Average	Average
Chemical Technicians	Increased Demand	Slower than average	Little or no change
Commercial and Industrial Designers	Increased Demand	Average	Average
Occupational Health and Safety Specialists	Increased Demand	Average	Average
Production, Planning, and Expediting Clerks	Increased Demand	Slower than average	Little or no change
Structural Iron and Steel Workers	Increased Demand	Slower than average	Average
First-Line Supervisors of Mechanics, Installers, and Repairers	Increased Demand	Average	Slower than average

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Electrical and Electronics Repairers, Commercial and Industrial Equipment	Increased Demand	Average	Slower than average
Industrial Machinery Mechanics	Increased Demand	Average	Average
Millwrights	Increased Demand	Slower than average	Little or no change
First-Line Supervisors of Production and Operating Workers	Increased Demand	Decline slowly or moderately	Decline slowly or moderately
Electrical and Electronic Equipment Assemblers	Increased Demand	Decline rapidly	Decline rapidly
Engine and Other Machine Assemblers	Increased Demand	Decline slowly or moderately	Decline slowly or moderately
Structural Metal Fabricators and Fitters	Increased Demand	Little or no change	Little or no change
Team Assemblers	Increased Demand	Little or no change	Little or no change
Computer-Controlled Machine Tool Operators, Metal and Plastic	Increased Demand	Decline slowly or moderately	Average
Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	Increased Demand	Decline rapidly	Decline rapidly
Drilling and Boring Machine Tool Setters, Operators, and Tenders, Metal and Plastic	Increased Demand	Decline rapidly	Decline rapidly
Welders, Cutters, and Welder Fitters	Increased Demand	Slower than average	Little or no change
Solderers and Brazers	Increased Demand	Slower than average	Little or no change
Chemical Plant and System Operators	Increased Demand	Decline rapidly	Decline rapidly

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Chemical Equipment Operators and Tenders	Increased Demand	Decline slowly or moderately	Decline rapidly
Mixing and Blending Machine Setters, Operators, and Tenders	Increased Demand	Decline slowly or moderately	Faster than average
Laborers and Freight, Stock, and Material Movers, Hand	Increased Demand	Little or no change	Little or no change

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

Evidence supports the continued viability of the 23 green new and emerging occupations identified in the 2009 report (see Appendix C). For example, photonics-powered production has been described as “powerful technology” for advanced manufacturing and investment in the industry appears to be increasing (Analytica-world, 2011; Pearsall, 2011). Expansion of nanotechnology continues and the technology is being incorporated in a wide variety of products and sectors, with increased investment and increased commercialization (RNCOS, 2011). Green logistics activities continue to draw interest as companies look to manage the environmental or carbon “footprint” of their production activities (Meyer, 2010). In addition, certification programs continue to be developed and offered in relation to transportation and logistics (APICS, 2011; CSCMP, 2011; ELAC, 2011). Finally, respondents for each of these green new and emerging occupations have been identified and surveyed since 2009 (see Appendix C).

Section II-11: Recycling and Waste Reduction

Sector activities encompass solid waste and wastewater management, treatment, and reduction, as well as processing of recyclable materials (Green Jobs Guidebook, 2008; McCarthy, 2008; Perry, 2008). This sector includes municipal waste and recycling as well as wastewater treatment and management. Many firms within this sector typically specialize in designing and manufacturing water purification products. Other firms focus more heavily on managing recycling and/or waste treatment operations. A recent trend in this sector is an increased focus on reducing “e-waste” generated by disposal of consumer electronics (e.g., computers, cell phones, etc.). According to research by International Data Corporation, approximately 3.5 million tons of electronics were recycled in the U.S. in 2010, which employed more than 30,000 workers with estimated revenue of over $5 billion (Gerlat, 2011). The Institute of Recycling Industries

counts among its 1600 members roughly 350 firms specializing in recycling e-waste (LeBlanc, 2011).

This green sector appears to have experienced significant growth in the past few years. This growth has been attributed to such as factors as high prices for energy and metals, rising costs for natural resource extraction, and concerns over pollution (Prouty & Glover, 2011). A recent report by the Southeast Recycling Development Council summarized regional growth in this green sector:

> "According to the S.C. Department of Commerce Recycling Market Development Advisory Council, the South Carolina-based recycling industry announced more than $438 million in capital investment in 2010. That investment created 1,130 new jobs with 28 new or existing companies for the state… A recent study by the North Carolina Division of Environmental Assistance and Outreach finds that more than 15,000 North Carolinians are employed by statewide recycling companies specifically. Those jobs add up to an impressive payroll of more than $395 million. State officials say recycling continues to be a driver of economic activity and job growth for the state. Scott Mouw, State Recycling Program Director details, 'Successive studies from 1994-2010 have shown consistent increases in recycling employment in the Tar Heel state. Our latest study documents that despite the deepest recession in decades, recycling jobs in North Carolina grew by nearly five percent in the last two years" (SRDC, 2011).

Existing evidence also suggests growth across specific segments of this sector (see Table 19 below) (Muro et al., 2011).

Table 19. Brookings Institution Data for Recycling and Waste Reduction Sector

Recycling and waste reduction segment	Percent Change 2003-2010	Direct Jobs 2010
Recycling and Reuse	5.4	129,252
Waste Management and Treatment	3.3	386,116
Recycled-Content Products	0.8	59,712

Workforce Implications

Investments by state and local government programs to increase recycling continue to shape this sector. In terms of occupational greening, the 2009 report described this sector's consequences as primarily enhancing competencies of existing occupations and generating new occupations. Two green enhanced skill occupations were identified: hazardous materials removal workers and refuse and recyclable material collectors. Two green new and emerging occupations in this sector were also designated: recycling

and reclamation and recycling coordinators. Appendices B-C provide descriptions of these four occupations.

Current evidence suggests that employment demand is strong for the two green enhanced skill occupations, with projections of 14-19 percent growth through 2018. Appendix D provides examples of the new green tasks associated with these occupations. Although new trends in e-recycling appear to be creating the need for additional specialized competencies, these new requirements fall within the scope of the two green enhanced skill occupations previously identified in the 2009 report. Thus, updating the existing list of green enhanced occupations for this sector does not appear necessary at this time. Evidence continues to support the viability of the two green new and emerging occupations, with numerous certification and degree-granting programs currently in existence (CRU, 2011; PRP, 2011; Rutgers University, 2011). In addition, data collection efforts for these two green new and emerging have been successful (see Appendix C).

Section II-12: Governmental and Regulatory Administration

This sector includes activities by public and private organizations associated with conservation and pollution prevention, regulations enforcement, and policy analysis and advocacy. Within public or governmental organizations, many of this sector's activities involve conservation and pollution prevention efforts and creation and enforcement of regulations. In addition, non-profit organizations are frequently involved with policy analysis and advocacy related to conservation, climate change, and other energy related issues. Profit-oriented organizations, such as venture capitalists and private equity firms, are often engaged in financing small- and large-scale renewable energy projects and other green technology projects. The employment landscape of this sector has shown growth, with a 5.9 percent increase in jobs between 2003 and 2010 to a total of 141,890 jobs in 2010 (Muro et al., 2011).

Workforce Implications

The 2009 report concluded that an increase in the activities related to this green economy sector would translate into a demand for both specialist-type occupations (e.g., testing specialists, researchers) and more general occupations related to regulation or administration (e.g., compliance managers, policy advisors). With regard to the greening of occupations, this sector was described as having at least some consequences for all three occupational categories, but mostly for the enhanced skill and new and emerging categories. Agriculture inspector was the lone green increased demand occupation identified for this sector in the 2009 report. Nine green enhanced skills occupations were designated and included occupations such as soil and water conservationists, environmental engineers, urban and regional planners, and arbitrators, mediators, and conciliators. In addition, seven occupations were indentified as green

new and emerging occupations. Among these were chief sustainability officers, compliance managers, energy auditors, regulatory affairs managers, and sustainability specialists.

Since 2009, evidence supports the continued and consistent impact of this sector on employment demand and occupational requirements. The one green increased demand occupation is predicted to show employment growth through 2018 (see Table 20 below for BLS projections). Of the nine green enhanced skill occupations, all but one is forecasted for employment growth through 2018. Research for the present report also did not find significant evidence of new technology or regulatory activity pertaining that would warrant additions to the list generated in the 2009 report. Examples of new green tasks for green enhanced skill occupations are provided in Appendix D.

Table 20. BLS Projections for Governmental and Regulatory Administration Sector Occupations

Occupation	Green Category	2006-16 Growth	2008-18 Growth
Financial Analysts	Enhanced Skills	Much faster than average	Much faster than average
Environmental Engineers	Enhanced Skills	Much faster than average	Much faster than average
Nuclear Engineers	Enhanced Skills	Average	Average
Soil and Water Conservationists	Enhanced Skills	Slower than average	Average
Urban and Regional Planners	Enhanced Skills	Faster than average	Faster than average
Arbitrators, Mediators, and Conciliators	Enhanced Skills	Average	Faster than average
Construction and Building Inspectors	Enhanced Skills	Faster than average	Faster than average
Inspectors, Testers, Sorters, Samplers, and Weighers	Enhanced Skills	Decline slowly or moderately	Decline slowly or moderately
Transportation Vehicle, Equipment and Systems Inspectors, Except Aviation	Enhanced Skills	Faster than average	Faster than average
Agricultural Inspectors	Increased Demand	Little or no change	Average

Note. Decline rapidly = -10% or lower; Decline slowly or moderately = -3% to -9%; Little or no change = -2% to 2%; Slower than average = 3% to 6%; Average = 7% to 13%; Faster than average = 14% to 19%; and, Much faster than average = 20% or more.

Evidence continues to support the viability of the seven green new and emerging occupations. For instance, the Global Institute of Sustainability reports that "sustainability skills" often provide job candidates with an advantage when they apply for jobs in the existing corporate structure and more executive-level sustainability positions are likely to be added in the medium term (Global Institute of Sustainability, 2011). Minnesota's iSeek program predicts significant growth for regulatory affairs and compliance professionals (31 percent between through 2019), with much of this growth related to green economy activities. Several professional associations, such as the International Society of Sustainability Professionals, and degree-granting programs have developed for occupations in this sector. For instance, Arizona State University offers sustainability concentrations at both the bachelors and masters levels (see www.sustainability.asu.edu) and DePaul University offers a business certificate in sustainability (see www.learning.depaul.edu). Finally, respondents for the seven green new and emerging occupations have been identified and surveyed since 2009 (see Appendix C).

Conclusions

Since the 2009 green report, updated research on the green economy illustrates that all 12 green sectors are still prevalent and discussed throughout the extant green literature. However, there are varying levels of activity within each sector (see Table X). The sectors with the highest levels of activities include Renewable Energy Generation and Recycling and Waste Reduction. Research related to renewable energy continues to be the forerunner among the focus of the green economy. In addition, Recycling and Waste Reduction remains significant due to rising costs of energy and metals and natural resource extraction, and state and local government investments in recycling programs. Sectors with moderate levels of activity include Transportation, Energy Efficiency, Green Construction, Research, Design, and Consulting Services, Environment Protection, Agriculture and Forestry, and Governmental and Regulatory Administration. As mentioned throughout the above sections, these sectors are exhibiting steady or increasing growth. Energy Trading, Energy and Carbon Capture and Storage, and the Manufacturing sectors all show signs of lower levels of activity within the green economy, due in part to the overall global economic slowdown.

SECTION III: CHALLENGES FACING THE GREENING OF OCCUPATIONS

Much has been written in the past three years about the challenges facing the green economy, both domestically and internationally, including discussions of the broader forces shaping the green economy overall, as well as discrete factors within specific

sectors. Among the broader forces frequently mentioned as impacting the green economy are inadequate fossil fuel supplies to meet ever-increasing global demand, concerns over linkages between greenhouse gas emissions and climate change, and how to continue promoting clean technology development and adoption during the recent economic recession. Although certainly applicable to the green economy as a whole, several factors have been proffered as key to growth within green sectors as well. Here, concerns tend to encompass the need for human capital development and utilization as well as increased financial capital investment to promote technological innovation, consumer adoption, and industry stability.

A recent report sponsored by the International Labour Organization (Strietska-Ilina et al., 2011) described broader workforce "restructuring" as a major consequence of the greening of the economy and noted that such restructuring poses both benefits and drawbacks for employment and work itself. For example, results pertinent to the U.S. from the ILO report suggest that extractive industries, fossil fuel energy generation, and emissions-intensive manufacturing are likely to see flat employment or job losses due to intra-industry restructuring such as the introduction of sustainable production practices, energy and resource efficiency, clean coal, and carbon capture and storage. At the same time, results also point to significant employment gains from restructuring in industries such as renewable energies, green building and retrofitting, and water and waste management. This report further outlined three obstacles facing countries as they move to develop and expand green economy activities.

- Lack of enforcement of existing environmental regulations and the need for more detailed environmental protection legislation.
- Limited awareness and capacities of policy-makers to integrate human capital concerns (e.g., skill training) into policy responses.
- Weak coordination and reciprocity among inter-agency efforts and policies.

Challenges associated with green economy expansion from more domestically focused analyses highlight similar needs for human, financial, and technological investment as well as more coordinated inter-agency efforts. In addition, many authors point to the need for stronger domestic responses to increasing global competition in manufacturing and deployment of green technologies. In their 2011 report, Muro et al. summarized many of these domestic imperatives by concluding:

> *"As to what governments, policymakers, and regional leaders should do to catalyze faster and broader growth across the U.S. clean economy, it is clear that the private sector will play the lead role, but governments have a role too. In this connection, the fact that significant policy uncertainties and gaps are weakening market demand for clean economy goods and services, chilling finance, and raising questions about the clean innovation pipeline reinforces the need for engagement and reform. Not only are other nations bidding to secure global production and the jobs that come with it but the United States currently risks failing to exploit growing world demand. [Thus]*

…vigorous private sector-led growth needs to be co-promoted through complementary engagements by all levels of the nation's federal system to ensure the existence of well-structured markets, a favorable investment climate, and a rich stock of cutting-edge technology—as well as strong regional cast to all efforts."

Challenges described above are import to strategic workforce development as well. Continued and increased financial investments influence workforce development insofar as they allow or sustain efforts to research, design, and implement programs that facilitate workforce competence and competitiveness. One advantage of using the occupational greening concept is that it facilitates the identification of areas in the U.S. workforce that may benefit most in terms of financial and intellectual capital investments. That is, a focus on the consequences of green economy activities and technologies allows efforts, such as those aimed at designing and conducting specialized training and education initiatives, to be better positioned for greater impact. For example, green new and emerging occupations are those most in need of such investments as they represent new roles that will require intellectual capital that may not yet exist. Similarly, but to a lesser extent, green enhanced skill occupations may require training investments to update skill sets to meet the newer duties and/or knowledge requirements resulting from green economy activities and green technologies.

Yet, for human or intellectual capital development efforts to be most effective they must be based on a systematic assessment of training needs (i.e., the competencies of importance and to be trained). Thus, what is critically needed is the development of domestic system that identifies the essential competencies requisite to occupational roles within the green economy. Such competencies should reflect human capabilities that are most malleable or trainable, such as key knowledge and skill requirements. Although there have been efforts toward outlining the various competencies associated with occupations tied to the green economy, several key needs remain. First, there is a clear need for more concise definitions of what "green skills" are meant to entail. This would also include depicting the boundaries of such competencies by addressing the uniqueness of the knowledge and skill requirements (i.e., are the competencies new or are they manifesting in some unique fashion?). Second, there is a need for a systematic organization of green competencies. The approach most likely to be useful here is to generate a taxonomic depiction of the competencies required for occupations with a high probability of being changed by green economy activities and technologies (i.e., green enhanced skill and green new and emerging occupations). Lastly, any domestic effort at identifying key green competencies should strive to describe the linkages or crosswalks to existing national occupational information systems such as O*NET. This is especially important considering that research suggests some of the skills or knowledge required for occupations in the green economy are transferrable to or from other more traditional "non-green" occupations (Environment California, 2011; Krumenauer & Johnson, 2011; White, Dresser, & Rogers, 2010).

SECTION IV: GREEN NEW AND EMERGING OCCUPATIONS REVISITED

As part of reviewing the literature related to green economy activities and technologies published since the 2009 report, sources pertinent to green new and emerging occupations were collected and reviewed. This updating effort was focused on identifying any new candidate occupations that were not previously identified in the 2009 report research, as well as revisiting the existing candidates from 2009 report to ascertain if any warranted a change in status. In short, a review of the current literature since 2009 did not reveal any additional candidates for consideration as green new and emerging occupations that were not already found during the previous research effort.

With respect to the existing candidates from 2009 report, each was subjected to additional data collection that focused on obtaining information about overall employment and/or employment growth, available education or training programs or credentials, licensure or certification, national associations, and trade or professional journals. A total of 24 candidate occupations had been designated as “wait list” or as “do not recommend.” Wait list candidates were those near a critical mass to warrant inclusion in the O*NET-SOC system, but with insufficient additional evidence to push them into the inclusion category. Candidates with the status of “do not recommend” were those with very little evidence to support inclusion as green new and emerging occupations.

Appendix H provides more detailed summaries of findings for these 24 candidate occupations. In an overall sense, there was little new evidence to suggest that the past three years have seen significant development or growth to warrant substantial upgrades to existing status designations. Cumulating the prior evidence from the 2009 report and newer research for this report, five status change recommendations listed below in Table 21 appear warranted (see Appendix H for more details).

Table 21. Candidate New and Emerging Occupations Recommendations

Candidate	Status	Recommendation
Solar Resource Assessors	DNR	Remove as candidate N&E list
Residential Air Sealing Technicians	DNR	Remove as candidate N&E list
Testing Adjusting and Balancing (TAB)Technicians	DNR	Consider upgrading to green N&E
Research and Development Engineers	DNR	Remove as candidate N&E list
Organic Farmers	DNR	Consider upgrading to green N&E

SECTION V: CONCLUSION

In this report we sought to assess the sustainability and impact of the occupational greening concept offered in our original 2009 report. Toward this end, we first reviewed the broader literature in order to describe the current state of the world of work in relation to green economic activities. We examined the influence and generalizability of the occupational greening concept as well as compared and contrasted it to other important definitional approaches (e.g., BLS definitions). The evidence we reviewed suggests that the occupational greening concept has had a meaningful impact on other green economy research, state labor market information systems, and training and development initiatives. In addition, the occupational greening concept provides a unique contribution compared to other definitional approaches and thus, is best viewed as complementary to these approaches. This report next offered a sector-by-sector updated review of any important changes and trends occurring over the past three years. The emphasis here was to uncover new evidence relevant to recent occupational changes within each green sector that might hold implications for occupational greening. Overall, the majority of technological trends, work implications, and occupational consequences previously identified in the 2009 report appear to remain; albeit some development slowdown has occurred as a result of the sluggish global economy. Third, we outlined several workforce development challenges facing the green economy from an occupational standpoint. Among these challenges was the importance of sustaining and increasing both financial and human capital investment. From an occupational perspective, it was argued that an essential need relates to a national taxonomic approach to designating competencies (knowledge and skills) associated with occupational performance tied to green economic activities and technologies. The final section of this report summarized a re-examination of candidate green new and emerging occupations that previously did not display sufficient evidence to warrant inclusion to the O*NET-SOC system. Current evidence suggested that, of the prior 24 candidates, three should be removed and two may warrant “full status” as potential green new and emerging. Further, no new and emerging occupation candidates were identified beyond the prior list during the research for the present report.

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