MINNESOTA'S EMERGING GREEN ECONOMY:

GREEN JOBS REPORT 2011

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Minnesota's Emerging Green Economy: Green Jobs Report 2011

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Foreword

Based on 27 years experience working on the progressive end of environmental and sustainable development programs, I can confidently say that the green economy is for real and has been for some time, long before the fervor surrounding our current political dialogue started. So is the sustainability movement, which is gaining momentum in all sectors both with the consumer and in the market place. Ultimately market transformation will become the primary driver for a 21st century clean-green-sustainable economy. These conclusions are based on a growing body of evidence including this latest green jobs report.

The first piece of quantitative evidence resulted from efforts dating back to the early 1990s, when Minnesota's focus was to establish and nurture high value-added manufacturing in the region. In 2004 and 2011 the Minnesota Pollution Control Agency conducted economic forecasting on the recycled goods manufacturing sector. The first study found a total of 19,260 estimated jobs and $2.8 billion in estimated gross economic activity annually. The second study, conducted in 2011 after a three years recession, revealed that total estimated jobs had risen to 36,980 and estimated gross economic activity to $3.8 billion annually.

More quantitative evidence came from a 2009 Pew Charitable Trusts study based on data from 1998 to 2007. In this 10-year period, clean-energy jobs in Minnesota rose from 17,868 to 19,994, corresponding to an average annual growth rate of 1.38 percent. Furthermore, nearly $50 million in venture capital was invested in the state from 2006 to 2008. The count of clean energy businesses in the state was 1,206 and related patents 218.

A third source of evidence came from a study by the Metropolitan Policy Program at the Brookings Institute in June 2011. It concluded that the clean economy for the Minneapolis-St. Paul Metropolitan Area ranks 11th out of the 100 largest metro areas, with 37,750 green jobs representing 2.2 percent of all jobs in Minnesota. Between 2003 and 2010, the Metro area added 11,231 jobs, with 5.2 percent annual growth. The estimated median wage for green jobs was $44,388 compared to $43,611 for all jobs.

Now we have the implications from this report by the Department of Employment and Economic Development, based on a study period between late 2009 and mid-2011. Key findings from the report offer more evidence that a distinctive Minnesota green economy is emerging and that green jobs, a key indicator of a growing green economy, are real and widely diffused.

The report also provides evidence that green jobs have good value to a worker because of higher than average wages, predominance of full-time opportunities, and diversity across regions, occupations and industries. Furthermore, the evidence of a disproportionate representation of green jobs in manufacturing (especially advanced manufacturing) suggests that the green economy could help strengthen our state's competitiveness in high value-added sectors. Minnesota will need to improve the systems that support innovation and train the workforce in technical fields economy-wide in order to meet the growing demand for advanced skill levels necessary for these jobs.

What is the Green Economy?

Any economy consists of the use of material and labor resources for the production and distribution of consumer goods and services. A green economy, sometimes referred to as the clean economy or clean energy economy, puts primary value on environmental performance, which is then rewarded in the marketplace.

What is distinctive about the green economy? First, in a green economy everyone will have to adapt to new technologies that enable efficiency gains and overall higher environmental performance: firms, workers, consumers, communities. Evolving green technology is one of the most important driving forces behind the green economy. Second, businesses that internalize the full costs of their products and services, and ensure their products are designed and manufactured in the safest, most ecologically responsible and economically efficient manner, will gain a competitive advantage. Third, quality-of-life and standard of living will become less about overconsumption and more about balancing ecological stewardship with economic prosperity, and in so doing, avoiding the degradation and depletion of natural assets. By reversing the degradation of ecological services, natural capital will continue to increase in value and become a major economic driver.

Advancing the green economy will require progression from an environmental management approach built on compliance, remediation, pollution control and waste management towards strategies based on pollution prevention, energy and resource productivity, and a platform of more restorative clean technologies. These strategies will drive optimal use of resources, internalize the full costs of production and measures of ecological health, and guarantee more balanced prosperity. They represent a paradigm shift, sometimes referred to as the "next industrial revolution," that will become a foundation for long-term global competitiveness.

What are the Key Drivers of a Green Economy?

Several market-driven factors are pushing firms to go above and beyond the fulfillment of regulatory compliance requirements, in order to address inefficient systems of production that do not fully internalize costs. The primary driver for the integration of sustainability into overall business strategies is the increasing impact of resources like energy, materials and water on the cost of doing business. Minimizing the costs and liabilities of resource waste is increasingly viewed as a profitable, not an optional, path. Other important drivers of change are stakeholders, including customers, investors, employees, and communities, who are starting to appreciate the value creation power of sustainability and thus pay attention to the social, environmental and economic impacts of business activities beyond quarterly growth and profit measures. Benefiting from capital and investment flows, forward-looking firms are embracing sustainability initiatives without having to wait for consumer preferences to change in large scale. In conclusion, a company's ability to manage resources and take into account environmental risks is a strategic issue that can create or destroy opportunities to do business, create brand value, and ensure operational continuity.

A final consideration must be added to quantitative evidence. It has been my observation that today's young people have a rising awareness that economic, environmental, and social values go hand in hand. It is my hope that this awareness will translate into future consumer power as well as business and government leadership. Future generations of political leaders and business people will have to act with urgency to respond to climate change, resource depletion, and global conflicts caused by growing insecurity and inequality of access to scarce resources. Their chance of success will be greatly enhanced by our willingness and ability to act collectively now to advance a truly green economy.

Timothy Nolan

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Executive Summary

In his first address to Congress in February 2009, President Obama made it clear that he sees a direct link between America's long-term economic interests and the development of clean energy. But do we, as a nation, have the companies, technology and human resources we need to make this happen? Minnesota's green jobs research project, funded through an American Recovery and Reinvestment Act (ARRA) grant,[1] focuses on the labor market side of this question.

This two-year study broadens the focus on clean energy to encompass jobs in the entire green economy in Minnesota. The research is built on Minnesota's Job Vacancy Survey because job vacancies provide a leading indicator of changes in the labor market, including changes in occupational demand, as well as skill, knowledge, education, and training requirements of occupations. The project included four rounds of a mail survey to employers, follow-up phone interviews with all employers with potentially green job vacancies, and in-depth interviews with a subset of key green firms in Minnesota.

Specifically, the purposes of this study are to:

- Define the impact of the green economy on the labor market in Minnesota;
- Quantify hiring demand for green jobs over a two-year period;
- Characterize green jobs in terms of occupational, industrial, and geographic composition;
- Collect comprehensive data on the skill, training, and certification requirements of green job vacancies to identify skill gaps and help students and career seekers prepare for in-demand green careers.

Findings from this study have been used to develop career information for job seekers, students and general career exploration. The Minnesota Green Careers Portal can be found at www.MnGreenCareers.org

Key Research Findings: A Profile of Minnesota's Green Jobs

This study defines a green job as one that is directly related and/or essential to a green product, green service, or green process. Survey respondents were asked if each of the positions they were hiring for would spend at least 50 percent of the time in any of the following activities:

- Renewable Energy or Alternative Fuels
- Energy and/or Resource Efficiency
- Environmental Cleanup (including recycling and pollution prevention/ mitigation activities)
- Sustainable Agriculture or Natural Resource Conservation
- Environmental Education, Regulation, Compliance, or Research

[1]Thirty awards were made to State Workforce Agencies, with some joint and some single state projects.

Based on this definition, green job vacancies represented 2.5 percent of overall hiring demand in Minnesota between fourth quarter 2009 and second quarter 2011. This estimate is in line with survey results from other states, which attempted to estimate the size of the green economy.[2] Green vacancies were found in 263 firms, predominantly privately owned, across the state with about half in the Twin Cities metro area and half outside of the metro area. By firm size, very small establishments (fewer than 10 employees) had the highest concentration of green job vacancies (29 percent).

With its diversified economy, Minnesota has a piece of just about every possible green activity, from long-standing reforestation to cutting-edge research on biopolymers. While green vacancies were reported in a wide variety of industries, the greatest numbers were in Construction and Manufacturing. The presence of green vacancies in manufacturing sectors where Minnesota already has a competitive advantage in terms of employment concentration, firm concentration, and locally available workforce, suggests that the greening of the economy could contribute to strengthening the state's manufacturing base.

The following list describes the relative size and distinguishing characteristics of Minnesota's green economic activity categories:

- *Energy and Resource Efficiency* (31 percent): These jobs contribute to designing, manufacturing, installing, maintaining, and/or selling products or services that increase energy and resource efficiency. This sector benefits from Minnesota's extreme climate, strict building codes, and opportunities for long term energy savings.
- *Recycling and Pollution Prevention* (22 percent): These jobs focus on reusing/recovering materials, manufacturing low-impact and non-toxic products, and reducing the carbon footprint of transportation and manufacturing activities. Minnesota has a strong recycling sector that supports local manufacturers by creating a market for industrial byproducts and materials recovered from solid waste. This category also has an important R&D component in Minnesota, specifically in green chemistry and bio-based plastics.
- *Natural Resource Conservation* (13 percent): These jobs contribute to conserving the natural resources that Minnesota has in such abundance, and ensuring their most efficient use. Public sector hiring was the most concentrated in this green category, with government establishments accounting for 80 percent of all openings.
- *Environmental Compliance* (12 percent): These jobs contribute to enforcing environmental regulations, certifying environmental practices and products, and increasing public awareness of environmental issues. The sector also includes environmental science research and fundraising for conservation-related issues.
- *Renewable Energy (*11 percent): These jobs involve the generation, storage, and distribution of power from renewable sources or alternative fuels. As a state with good wind potential and abundant agricultural feedstock, Minnesota has an incentive to invest in renewable energy sources and biomass fuel sources.
- *Pollution Control* (8 percent): These jobs contribute to pollution control/mitigation and waste treatment. Given the myriad pollution sources and problems, businesses face the challenge of identifying viable and effective cleanup options, with solutions coming from a variety of disciplines.
- *Water Treatment and Conservation* (3 percent): These jobs contribute to cleaning up, conserving, and optimizing the use of water resources. Issues of water quantity and quality are destined to become strategic for economic development.

Key Research Findings: Characteristics of Minnesota's Green Job Vacancies

Hiring for green jobs was dispersed across a wide variety of occupations over the study period. However, over

[2] Since the survey was constructed to measure job vacancies, not current jobs, the data collected cannot be interpreted to determine the size of the green economy in Minnesota.

half of all green job vacancies were concentrated in Installation, Maintenance, and Repair; Architecture and Engineering; Construction; and Management and Business Specialists. Although green jobs are not a new phenomenon and generally fit within current occupational taxonomies, workforce competencies for these jobs are undergoing a gradual transformation as an effect of ever-changing technology and increases in the amount of time dedicated to green tasks.

Overall, green vacancies tend to be higher quality than total vacancies with predominantly full-time (89 percent) and permanent/non-seasonal (79 percent) opportunities and high wage offers. The higher wages appear to be driven, on the one hand, by higher concentrations of green jobs in better paying occupations (business specialists and engineers) and better paying industries (advanced manufacturing) and, on the other hand, by a "wage premium" associated with specialized, sometimes unique, knowledge and experience required to perform green tasks.

Key Research Findings: Education, Skill and Knowledge Requirements

Green vacancies require a higher education level than other vacancies. The most common degrees required to work in green jobs were Bachelor's and vocational degrees, while the most highly demanded fields of study were engineering and science. This suggests that higher education institutions and vocational trade schools, especially those delivering science, technology, engineering, and mathematics (STEM)-related programs, will have an important role to play in building the local talent businesses need to compete in the marketplace as the economy adopts green concepts.

The majority of green vacancies required technical skills, often linked to the use of new technologies that are driving the greening of the economy. Technical and mathematical skills combined were required in 48 percent of all green vacancies, indicating high demand for candidates who can blend the two skill sets. Technology design, cited as important in 13 percent of green vacancies, reflects the research and design activities currently taking place in Minnesota. Project management, which combines technical and managerial skills, was also cited as important by employers because green activities often come in the form of interdisciplinary projects. Overall, strengthening STEM at all levels of the educational system will support Minnesota's green economy and prepare the future workforce for these jobs.

Key Research Findings: The Future of Minnesota's Green Jobs

Growth in hiring demand for green-related work was virtually identical to that in the overall economy, averaging 30 percent over the study period. However, 54 percent of positions were new rather than caused by employees' leaving. Since newly created positions represent growth openings created by economic expansion, this finding demonstrates the emerging nature of Minnesota's green economy. Moreover, this growth will likely occur in very small or small firms,[3] which hold the highest share of newly created positions and also the highest share of green vacancies statewide.

Future job growth in the green economy will be driven by technology advancements, evolving consumer demand for green products/services, and the pace of adoption of green practices and processes within individual firms. As the concept of environmental performance becomes broader and more holistic, more interventions will be focused on tackling problems from the early stages of a product's commercial cycle rather than managing emissions and wastes downstream. Thus, green activity categories focused on pollution prevention, efficiency, and renewable energy may be the biggest areas of job growth.

The greening of the world of work is unfolding gradually and quietly. When certain products and services gain market acceptance as environmentally beneficial, and preferable compared to others, some jobs will be created and some will be lost. Although the prevailing impact will be a gradual modification of existing jobs, an element of radical job change is also expected as new green technologies will require enhanced workforce competencies compared to non-green sectors.

[3] Very small firms are defined as firms with less than 10 employees. Small firms are defined as having between 10 and 49 employees.

1 METHODOLOGY

The green jobs project used Minnesota's ongoing statewide Job Vacancy Survey (JVS), follow-up telephone surveys, and secondary research to study green jobs throughout the state. The JVS is a semiannual survey of employers in Minnesota, conducted in the spring and fall quarter of each year. The survey results produce estimates of hiring demand and job vacancy characteristics by industry and occupation. Surveys are mailed to a sample of 10,000+ employers who return them by mail or fax. Some employers allow us to collect job postings directly from their company website. Starting with the fall quarter 2009 survey round, and continuing through the spring quarter of 2011, a total of four survey rounds, sample size was increased to 12,000, and industries that were pre-identified as potentially green were over sampled. The last round of data collection ended in June of 2011. Return rates for all survey rounds were approximately 70 percent.

To identify relevant green positions, JVS respondents were asked if each of their vacancies fell into any of the following five green subcategories: renewable energy or alternative fuels; energy efficiency; environmental cleanup; sustainable agriculture or natural resource conservation; environmental education, regulation, compliance, or research. Each position that was identified as green was included for a follow-up phone survey. If a respondent did not answer the green question but was in a previously identified green industry, those vacancies were also selected for follow-up.

Analysts conducted follow-up telephone interviews with employers to confirm the environmental activities of each position and to gather qualitative information on education level, skill and knowledge requirements, and to learn whether employers faced difficulties finding qualified candidates for the position. The response rate for the follow-up interviews was 76 percent.

Determining the Greenness of Particular Positions

In order to determine the greenness of each particular position collected in our sample, we considered the degree to which the position was *directly related* and/or *essential* to a green product, green service, or green process. To determine the degree to which jobs were directly or essentially related to green, we considered these factors:

Job title: We took job titles into account to a degree. However, job titles do not always accurately reflect job duties or the primary focus of the job. For instance, a boiler operator might focus exclusively on the efficient operation of multiple boilers in a large industrial plant, likely to contribute to energy efficiency, or s/he may do light boiler work but spend the majority of time doing general facility maintenance, likely not to contribute to energy efficiency.

Job duties: Job duties helped us determine whether the work done was directly or essentially related to green products, services, or processes. For instance, a gardener whose duties include manicuring lawns, tending flower gardens, and pruning shrubs is likely not green. A gardener who grows native plants and who offers consultation services to people who want to create rain gardens using compost and organic fertilizers is very likely green.

Degree to which duties fell within green subcategories: Greenness was also based on the degree to which employers reported that the job duties fell within specific green subcategories. As in the original JVS survey, subcategories included renewable energy or alternative fuels; energy efficiency; pollution reduction, prevention, or remediation; sustainable agriculture or natural resource conservation; and environmental regulation, compliance, research, or advocacy.

Percentage of time spent in green activities: If, after collecting data about the job title, job duties, and whether job duties fell within green subcategories, it was not clear whether the job should be coded as green, analysts asked the employer for an estimate of the percentage of time the position spent on green subcategory duties. These percentages helped us make final determinations about a position's greenness. For instance, a plumber might work in renewable energy, e.g., geothermal lines, but if that only accounted for 10 percent of his/her overall time, it did not indicate as a sole factor that the job was green. But if a plumber spent 80 percent of his/her time on geothermal systems, then the job would likely be coded as green.

Employer perspective: Employer perspectives about whether jobs were green were also considered. However, in some cases, analysts overrode employers' assessments. For instance, an employer might say their truck drivers were green because they used low-sulfur diesel. But in our assessment that factor alone did not make a job green, and we would likely have overridden the employer assessment. If, however, their drivers were primarily transporting organic fruit to local markets or specializing in transporting solar panels, then we would have been more likely to agree with the assessment that the positions were green.

Organizational context: We also considered the degree to which the larger organizational context was green. For instance, someone working on an assembly line to produce standard diesel engines would not be considered green while someone working on an assembly line to produce wind turbine blades would be considered green. The nature of the position (assembly line work) may not vary significantly from organization to organization, but the end product helped determine the greenness of the position. However, just because an organization focused on a green product or service did not mean that all positions within that organization would automatically be considered green. Jobs that were neither direct nor essential to the product or service would not be considered green. Non-green jobs at green organizations would generally include positions such as security guards, HR personnel, administrative assistants, janitors, and so forth.

Data Analysis

After completion of each survey round, the data were scaled to produce estimates representative of Minnesota's labor market by Planning Area. At the end of the last survey round, data for green vacancies were aggregated to provide more robust estimates by occupation, industry, and region. In-depth interview data were passed through a series of quality reviews and coded according to categories that emerged from field data collection in an ongoing iterative process. Finally, qualitative survey data were linked to corresponding quantitative survey data and comprehensively analyzed.

2 A PROFILE OF MINNESOTA'S GREEN ECONOMY

With its diversified economy, Minnesota has a piece of just about every possible green activity, from long-standing reforestation to cutting-edge research on bio-based plastics.

The survey asked respondents to identify the environmental activities of their job openings by choosing among five core green-related sectors. Two new sectors were added to the original five as starting definitions were fine-tuned in light of empirical evidence.

The sectors are:

- Producing renewable energy or alternative fuels
- Increasing energy and resource efficiency
- Monitoring, controlling, and cleaning up pollution
- Preventing pollution through recycling, implementing green transportation technologies, and producing/using low-impact materials
- Cleaning up, conserving, and optimizing the use of water resources
- Conserving and restoring natural resources through wildlife/habitat restoration services and sustainable farming, forestry, fishing, and land management practices
- Providing environmental education, regulation, compliance, research, or support services for the previous categories

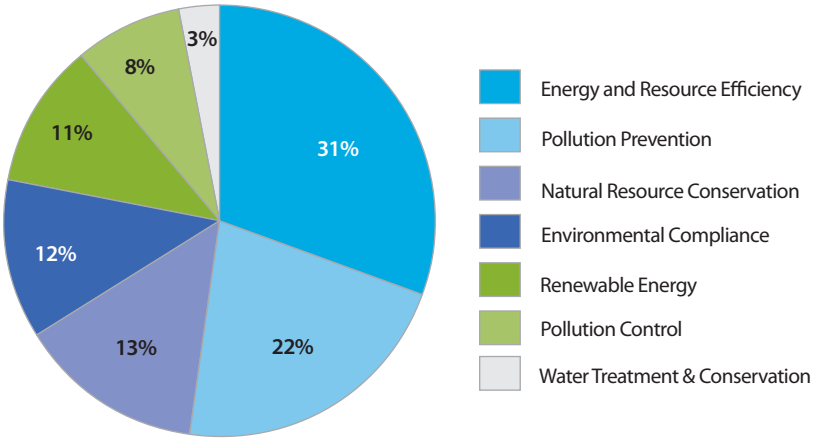
Figure 1 illustrates how green vacancies reported from fall 2009 to spring 2011 were distributed across sectors.[1]

[1] For the purpose of this analysis each job has been assigned to a predominant sector of focus even though there is often overlap among sectors.

FIGURE 1

Green Vacancies by Sector

Source: Green addendum to MN JVS, 2009-2011



Energy and Resource Efficiency

Energy and resource efficiency comprised 31 percent of job vacancies over the study period. Due to high energy consumption for heating during the cold season and for cooling during the summer, Minnesota has a higher per capita ecological footprint than most states, leaving room for efficiency gains. The commercial market is the most dynamic, including hospitals, campuses, and government entities interested in lowering their utility bills and offering healthier indoor living environments to their clients and employees. Commercial owners, particularly those who plan to hold on to their buildings long-term, are starting to understand the wisdom of investments in operational efficiencies. They see the benefit of improving the value of property assets for the long-term, while buffering against energy price volatility.

What makes this sector particularly strategic is its strong connection to Minnesota's manufacturing base and existing workforce skills. The top five industries with close ties to energy and resource efficiency, HVAC Systems Manufacturing, Precision Instruments Manufacturing, Automatic Environmental Control Manufacturing, Wood Window and Door Manufacturing, Glass and Glass-product Manufacturing, are all "distinguishing industries"- that is, they have a greater share of employment in Minnesota than in other states.

Recycling and Pollution Prevention

This sector made up 22 percent of green job vacancies. Recycling and pollution prevention jobs focus on reusing/recovering materials, manufacturing low-impact and non-toxic products, and reducing the carbon footprint of transportation and manufacturing activities.

The research identified the following pollution prevention practices with corresponding business opportunities all captured in this sector:

- Reducing the intensity of materials (and their embodied energy) in products and packaging. Reducing the amount of cardboard in packaging is an example of activity included in this sector;
- Reusing, refurbishing, and deconstructing products with the aim of extending their useful life. Thrift stores are a source of labor in this area;
- Recycling and recovering materials to produce recycled-content goods. Minnesota has a strong recycling sector that supports local manufacturers by creating a market for industrial byproducts and materials recovered from solid waste.

Lastly, the sector also includes R&D activities aimed at developing non-toxic chemicals and advanced bio-based plastics that can replace petroleum-based ones.

Natural Resource Conservation

Natural resource conservation made up 13 percent of green job vacancies in the study. Minnesota is blessed with abundant natural resources including water, agricultural land, and forests. The health of water and woods is integral to Minnesota's outdoor culture. People not only volunteer to preserve the beauty of natural parks and lakes, but work full-time in activities aimed at conserving natural resources and ensuring their most efficient use.

This was the area with the highest incidence of public sector employment: government establishments accounted for 80 percent of all hiring. Private sector hiring was underrepresented in the data because self-employed farmers were not included in the universe of surveyed establishments.

Environmental Compliance

This sector comprised 12 percent of the green job vacancies in our study. These jobs engage in activities that are indirect but essential to the delivery of green products and services. They include corporate headquarters positions such as environmental compliance managers and corporate sustainability specialists. Besides private corporations, hiring from nonprofits and government establishments was strong in this sector, with government establishments accounting for 50 percent of all hiring. Jobs included fundraisers for conservation-related activities and scholars engaged in applied research on environmental topics.

Renewable Energy

Renewable energy job vacancies made up 11 percent of the green job vacancies in the study. These are jobs that generate, store, and distribute power from renewable sources or alternative fuels, as well as using biomass feedstock as a form of renewable energy. This sector is strategic for the entire green movement because the technological solutions developed here can drive the epochal transition towards a carbon-free economy. As a state with good wind potential and abundant agricultural feedstock, Minnesota has an incentive to invest in renewable energy sources and biomass fuel sources.

Pollution Control

This sector comprised 8 percent of green job opportunities. These are jobs that contribute to pollution control/mitigation and waste treatment. Given the myriad pollution sources and problems, businesses face the challenge of identifying viable and effective cleanup options that are often "one-of-a-kind." The need for customized solutions often gives firms an incentive to internalize the expertise by hiring specialists from a variety of disciplines.

Water Treatment and Conservation

This sector comprised 3 percent of green job opportunities. These are jobs that contribute to treating and conserving wastewater as well as managing water resources. Although this sector provided the fewest openings, issues of water quantity and quality are destined to become strategic for economic development. Water is a critical input for agriculture, manufacturing, energy generation, and recreation. Moreover, Minnesota's perennial streams and municipal watersheds supply drinking water to a growing population.

Figure 2 illustrates Minnesota green economy sectors and detailed areas of specialization. High concentrations of vacancies identify high-demand areas over the last two years. Although the level of hiring is not a predictor of future investments in any of these areas, it offers a baseline to track the evolution of different approaches to green and how they might impact staffing patterns and business models.

It has to be noted that the segments' relative size is subject to change as fluctuations in the business cycle and evolving consumer demand shift priorities towards one or another green area. Moreover, about 24 percent of all vacancies had to be assigned to one green sector even though their work was almost equally divided between two green sectors. The most common cases of overlap were environmental engineers working simultaneously on environmental permitting (captured in the Environmental Compliance sector) and professional environmental services (captured in Pollution Control).[2] For these reasons, care should be taken when interpreting high and low numbers in the chart. Regardless of their individual magnitude, each segment represents green economic activities capable of creating jobs in Minnesota.

[2] A clear example of the difficulties encountered when assigning individual jobs to a unique green sector is provided by this sample response in reference to a production supervisor installing plastic covers over ponds, tanks, or landfills: "(The predominant sector the position is engaged in) depends on the project. Some projects are to line or cover landfills and to line or cover wastewater; others used to collect methane to co-generate electricity thus increasing energy efficiency and decreasing pollution."

FIGURE 2

Minnesota Green Economy Sectors and Detailed Areas of Specialization

	Detailed Segments	Estimated Green Vacancies	Examples of Products and Services
1. Renewable Energy and Alternative Fuel			
Renewable Energy Generation & Distribution	Wind	203	Wind turbine maintenance; geotechnical surveying, design and construction of cement foundations for wind turbines
	Geothermal	34	R&D, installation, and sale of geothermal technologies
	Solar (thermal and power systems)	21	Design and installation of commercial solar systems
	Waste-to-energy (feedstocks include solid, agricultural, and other biowaste materials)	13	Solid waste incineration to produce electric and thermal energy, landfill gas methane recovery and use
	Renewable energy services (not source-specific)	13	Infrastructure development (storage devices for renewable energy, high-voltage power grid design, construction permitting)
Alternative Fuel	Biofuel/biomass	134	Ethanol production, biomass fuel pellets manufacturing, logging operations that harvest waste-wood for biomass, agricultural biomass for power and fuels
Other	Other clean energy technologies	14	Co-generation; fuel cells, nano-materials, and thin film manufacturing
2. Energy and Resource Efficiency			
Design	Green architecture and construction services	34	Sustainable design services, LEED certification services, low-impact development practices
Energy Efficient Technologies	Energy-efficient construction services	243	Building inspection, plumbing, radiant floor heating, roofing, electrical work
	Energy-efficient HVAC and building control systems manufacturing and installation/repair	411	HVAC systems, wireless sensors, energy-efficient building retrofits
	Energy-saving construction supplies, appliances, and consumer goods manufacturing and installation/repair	276	Energy-efficient windows, roofs, insulation
	Energy-efficient building operations and professional energy management services	48	Energy auditing and commissioning, energy analysis, boiler operations
	Energy storage technologies manufacturing	99	Energy storage/harvesting solutions, lithium and other advanced batteries, energy efficient data storage solutions
	Advanced lighting products	<10	LED lighting, lighting controls
	Efficiency of the electric power grid (manufacturing and services)	64	Substation automation, advanced metering and control technologies, Smart Grid applications (software programs, demand response)
	Resource-efficient precision instruments and industrial process automation device manufacturing	15	Flow control systems; thermostats, energy measuring systems; smart meters; pumps; instruments for the detection of environmental changes (temperature or humidity, water leakage, power failures)
Water Conservation & Recovery	Water conservation practices and technologies	<10	Grey water recovery, water recycling, water reduction

FIGURE 2, *continued*

Minnesota Green Economy Sectors and Detailed Areas of Specialization

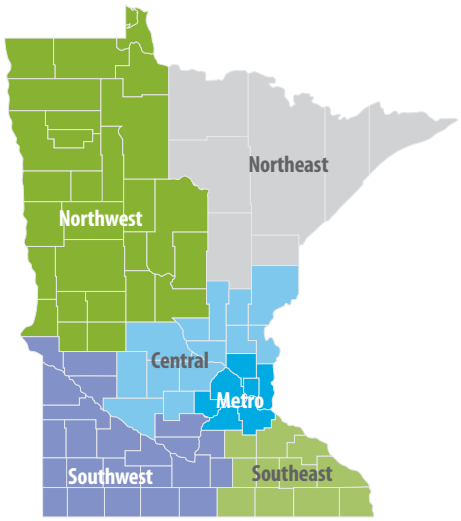
	Detailed Segments	Estimated Green Vacancies	Examples of Products and Services
3. Pollution Control, Remediation, and Waste Management			
Pollution Control & Remediation	Remediation services	130	Evaluation and remediation of contaminated sites, clean up, brownfield redevelopment, emergency response, asbestos removal
	Professional environmental services (investigation)	50	Environmental site assessments, hydrological assessments and wetland delineation, air quality consulting, air and water quality monitoring
	Air pollution control and monitoring equipment manufacturing and operations	48	Industrial ventilation systems, dust collectors, industrial air quality and greenhouse gas emissions monitoring, installing and doing feasibility studies for pollution control equipment
Waste Management	Waste treatment and end of life disposal	62	Hazmat removal services, landfills design, solid and organic (food) wastes composting
4. Pollution Prevention			
Resource Recovery	Recycling and reuse, both services and manufacturing	547	Recyclables collection and sorting, sale of second-hand and refurbished products
	Recycled-content goods and sustainable packaging manufacturing	148	Goods that contain recycled content, packaging that uses less material
Sustainable Materials	Sustainable materials manufacturing, including R&D and commercialization	26	Green chemistry (biopolymers, biodegradable products, coatings, biocomposites); non-toxic paints, non-toxic cleaning and toiletry products
	Services specializing in the use of low-impact, non-toxic materials	26	Construction, industrial and interior design, maintenance, and cleaning services specializing in the use of sustainable materials
Transportation	Green transportation technologies manufacturing	20	Low-emission vehicles and equipment such as electric and hybrid vehicles, natural gas vehicles; diesel technology; vehicle components/engines, catalytic converters
	Public mass transit	70	Bus and rail operations; mass transit planning and engineering
Processes	Waste minimization processes	26	Lean manufacturing and supply chain operations
5. Water Treatment and Conservation			
Treatment	Wastewater treatment services	42	Wastewater process and facility design, filtering and purification operations, plant operations, environmental analysis
	Water treatment and purification products	40	Water treatment filters, pumps, and valves
Management & Conservation	Stormwater management and conservation design	30	Low impact landscaping services; bank stabilization; stream restoration, floodplain analysis, stormwater recovery products

FIGURE 2, *continued*

Minnesota Green Economy Sectors and Detailed Areas of Specialization

	Detailed Segments	Estimated Green Vacancies	Examples of Products and Services
6. Sustainable Agriculture and Natural Resource Conservation			
Sustainable Agriculture	Organic food and sustainable farming	60	Organic/sustainable nurseries, promoting sustainable farming practices and conservation techniques such as manure management and feedlots
Natural Resource Conservation	Resource conservation and habitat/wildlife restoration	405	Forestry management/reforestation, wetland and prairie restoration, wildlife protection, nature park maintenance
	Land management and environmental planning	60	Soil management to prevent stream water pollution, land acquisition, environmental surveying and planning
7. Environmental Regulation, Compliance, Research, Advocacy, Education, and Other Support Services			
Business Support Services	Regulation and compliance	149	Air quality permitting, greenhouse gas emissions inventories, Environmental Health and Safety compliance, sustainable products certification
	Market research, business development, and corporate planning	5	Corporate sustainability planning; analysis of market demand for green products for commercialization
Advocacy & Education	Research, advocacy, public awareness, education and training	294	Academic research on environmental topics, advocacy and fundraising for conservation-related issues, delivery of vocational training in green skilled trades

Each sector and its segments represent a set of strategies for dealing with the myriad environmental issues this nation is facing. Different approaches can have different implications for the future. Some are "greener" than others in the sense of being more preventive and long-term as opposed to remedial and short-term. For example, pollution prevention as an environmental strategy differs substantially from pollution control. The ultimate purpose of pollution prevention is to minimize or avoid pollution before it happens, while the purpose of end-of-pipe solutions is to treat and clean up pollution occurring down the road. They are both important, but as the concept of environmental performance becomes broader and more holistic, more interventions will be focused on preventing problems from the early stages of a product's commercial cycle. That's where the most critical choices about raw materials safety, environmental sustainability, durability, and future life cycles can be made. Small efforts early in the product life cycle can save money and resources, protect brand image, and avoid liability for hazardous spills and damage to human health. As corporate and societal preferences shift from conventional treatment/control approaches to preventive approaches, the prevention, efficiency, and renewable energy segments may be the biggest areas of innovation and job growth.



3 GREEN VACANCIES BY REGION

Geographic Distribution of Green Vacancies

Green job vacancies represented 2.5 percent (3,882 vacancies) of overall hiring demand in Minnesota from fall 2009 to spring 2011.[3] The Twin Cities Metro Area accounted for a slightly larger share, 54 percent, of green vacancies compared to 46 percent reported in Greater Minnesota. Considering that 57 percent of total vacancies were concentrated in the Metro Area, the Minnesota green economy does not appear to be metro-dominated. Greater Minnesota might offer a comparable number of green job opportunities despite the fact that the Metro Area has the largest labor pool.[4]

A detailed geographic breakdown reveals a more varied picture. Figure 3 displays how green hiring activity was distributed by Planning Region. Demand for green jobs was highest in the Twin Cities and Central Minnesota, and lowest in Southeast and Northwest.

[3] Total vacancies were calculated by summing all estimated vacancies reported during the JVS survey rounds of fall 2009, spring 2010, fall 2010, and spring 2011. Since survey data are not collected year-round but for three months every six months, this figure does not represent two continuous years of hiring activity.

[4] 58 percent of total payroll employment is concentrated in the Metro Area.

FIGURE 3

Regional Distribution of Green Job Vacancies

Source: Green addendum to MN JVS, 2009-2011

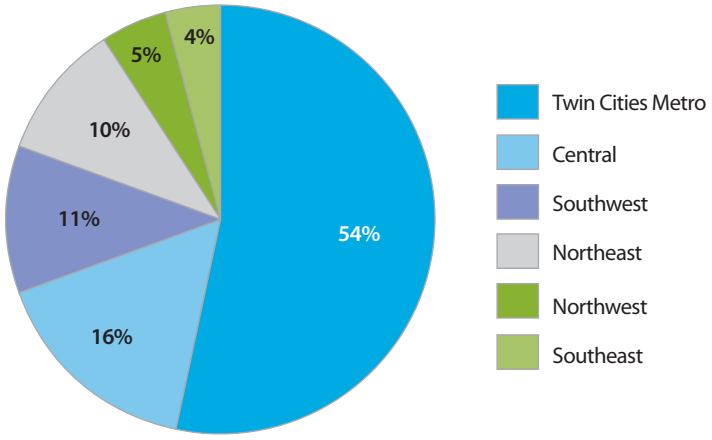


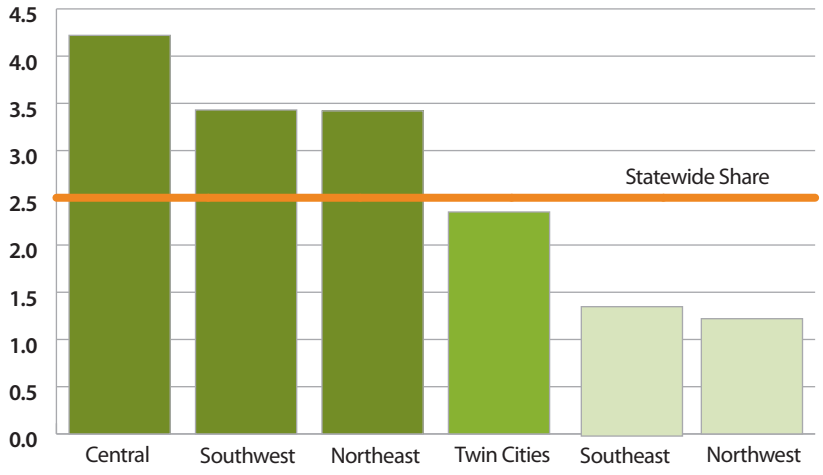
Figure 4 shows green vacancies as a share of total vacancies within each region. The orange line marks the share of green vacancies to total vacancies for Minnesota as a whole (2.5 percent).

It must be noted that vacancy data are measuring hiring for green jobs, not the greenness of one region compared to another. A region that is hiring a lot of environmental engineers may be doing so simply to keep polluting industries like coal-fired power plants or iron mining facilities in compliance with environmental regulations, not because they are producing green products or services. However, environmental engineers as an occupation are green regardless of what industries they are in.

FIGURE 4

Share of Green Vacancies to All Vacancies by Region

Source: Green addendum to MN JVS, 2009-2011



Furthermore, differences in hiring levels among regions could have been affected by the pace of recovery from the economic recession which differed from one region to another.

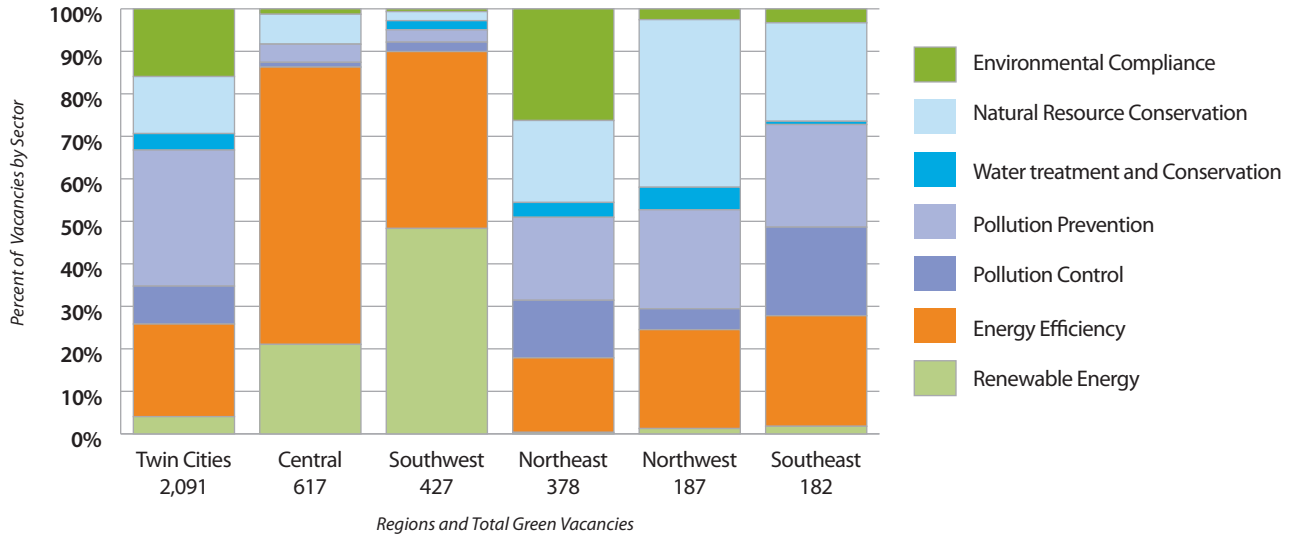
With these caveats in mind, the analysis revealed the following regional groupings:

- Share of green openings higher than 2.5 percent (dark green): regions that showed relatively higher demand for green jobs than other regions.
- Share of green openings about equal to 2.5 percent (green): regions (the Metro Area) where the proportion of green openings to total openings was about equal to the state as a whole.
- Share of green openings below 2.5 percent (light green): regions that showed relatively lower levels of hiring demand for green jobs than other regions.

Two regions, Southeast and Northwest, seem to have remained somewhat isolated from the green economy during the last two years.

FIGURE 5

Distribution of Green Job Vacancies by Sector and Region



It should be noted that regional and statewide contributions to the green economy from sustainable farming and/or organic food production could not be measured through vacancy data because family farms are not included in the universe of sampled establishments. This may cause the analysis to understate the share of green vacancies in the Southeast.

Green Regional Assets

What kind of green activities most characterize each region? Figure 5 shows the mix of green activities that define the green economy in each Planning Region. Differences in green activities are attributable to differences in the industry composition among regions.

Twin Cities

The Twin Cities metro area leads the state in several green activity categories because of the depth and breadth of its industry mix. Examples of industries uniquely located here are research & development, environmental consulting, IT, environmental advocacy organizations, academic research institutions, and administration of government programs regarding air, water, and waste. While some green activities in Metro-located service industries are oriented to out-of-state markets, for example corporate R&D divisions developing technologies for solar panels manufactured and sold outside Minnesota, others have linkages to industries located in Greater Minnesota. An example is software companies that are developing and selling "smart grid" and other IT solutions for energy-efficiency to utilities located in rural areas of the state. Green construction services also have the potential to deepen supply chain relationships between the Twin Cities and Greater Minnesota from the need to integrate more environmentally friendly products manufactured outside the Metro region into the built environment. Another example of urban/rural linkages is the installation and operation of wind turbines and electrical power lines in rural areas to supply electricity to urban residents.

In terms of sheer hiring volume, the region's main contribution to the green economy was for activities related to Pollution Prevention.

Corporate R&D activities for the development of sustainable materials are concentrated here, as well as mass transit planning authorities and major recycling operations. Energy Efficiency was the second most in-demand green sector, driven by the high concentration of buildings (new and existing) and the presence of architectural firms in this urban area.

Central Minnesota

Central Minnesota generated the second highest number of green job vacancies in the state after the Twin Cities. The region's main assets in the green economy are Energy Efficiency and Renewable Energy. The local manufacturing industry contributes to green product innovations in energy efficiency, while population growth is helping the recovery of residential construction and related energy-efficient services. The region also generated openings in Renewable Energy, especially geothermal.

Southwest Minnesota

An agricultural region and prime location for wind turbines, Southwest Minnesota leads the state in Renewable Energy with the local supply of corn and other agricultural feedstock. Jobs in energy efficient construction and building operations were also reported, while other green sectors had a very small presence in this region.

Northeast Minnesota

Activities related to Environmental Compliance were relatively more typical in this region than in others due to the uniquely high concentration of employment in government-regulated industries like mining and utilities. Other green sectors like Pollution Prevention and Natural Resource Conservation were also well represented, driven by the need to protect the abundant natural resources of the region such as lakes, streams, and forests.

Northwest Minnesota

The region's main contribution to the Minnesota green economy in terms of hiring activity came from Natural Resource Conservation, primarily represented by forest service jobs protecting the boreal forest and its eco-system.

Southeast Minnesota

Because of the presence of important manufacturers of energy efficient products, the largest number of green openings in this region fell into the Energy Efficiency category. The region also hosts organic farms that contribute to Natural Resource Conservation. Although self-employed farmers are underrepresented in the survey, some sustainable farming activities have been identified.

Limitations of the Use of Job Vacancy Data for Regional Comparisons

Care must be taken when doing cross-regional comparisons of green vacancies, for several reasons. First, job vacancies represent current hiring activity, not employment levels. Second, the timing of the survey complicates the comparative analysis of regional economies. In a normal business cycle more green enterprises in Northwest and Southeast Minnesota might have been represented in the study, but during the last recession entire industry sectors (such as the forest products industry in the Northwest) did not hire. The housing market, currently a huge wild card for the economy, might change the landscape again as construction activity in some regions is recovering faster than in others.

Despite these issues, it is clear that the urban-rural diversity of Minnesota's economy is key to the development of the local green economy. Every region in Minnesota is contributing to the creation of green jobs, with each region specializing in different green activities.

4

GREEN VACANCIES BY INDUSTRY

The Minnesota green economy mirrors the diversity of the state's industry mix. Green vacancies were spread across 120 industries as identified by the North American Industrial Classification System (NAICS), the prevailing standard for the classification of industries in the United States.

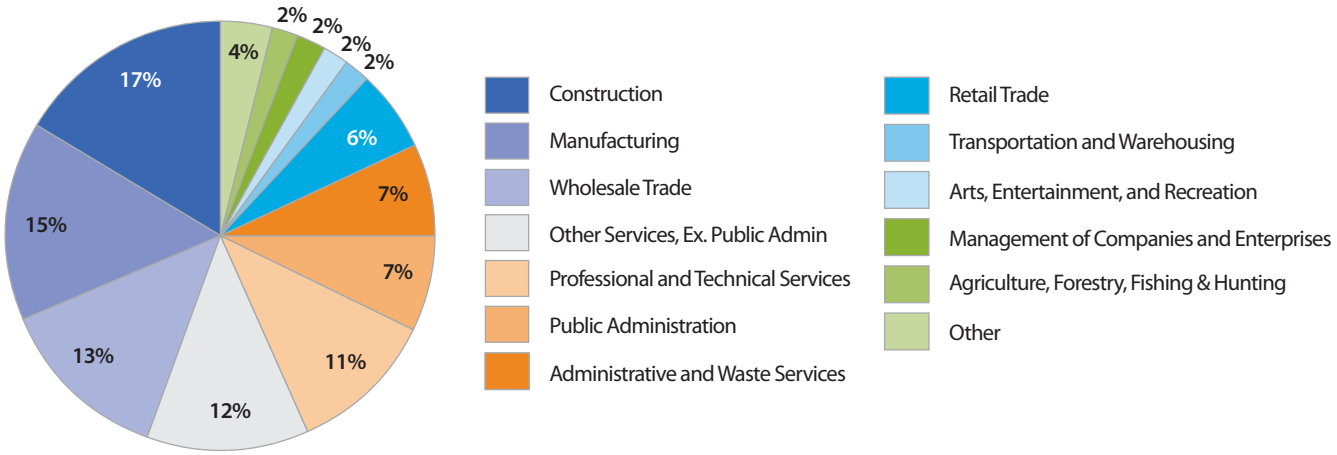
Green Vacancies by Broad Industry Group

The industry sectors generating the largest number of green job vacancies from fall 2009 to spring 2011 are summarized in Figure 6.

FIGURE 6

Green Vacancies by Broad Industry Group

Source: Green addendum to MN JVS, 2009-2011



The industries most likely to be impacted by the greening of Minnesota's economy are Construction and Manufacturing, which are intimately related to each other because of their contribution to energy and resource efficiency in the built environment.

Despite the fact that electricity in Minnesota is cheap compared to other states, the potential for energy and resource conservation in construction activities is high. The push toward energy and resource efficiency is also encouraged by rising costs of construction materials, stringent building codes in the state relative to other states, and the increasing popularity of labels for products that exceed standards (such as Energy Star) and certifications for buildings (such as Leadership in Energy and Environmental Design — LEED[5]). The construction industry also has great potential to create new green jobs both directly and indirectly through spillover effects to other industries such as facility maintenance services, architectural/engineering services, and, most importantly, manufacturing.

Manufacturing, not surprisingly, reported the second highest number of green job vacancies by industry. Besides being the "Silicon Valley of windows,[6]" Minnesota has a high concentration of employment in HVAC and environmental controls manufacturing, precision instruments manufacturing, and lighting and electrical equipment manufacturing. The presence of green jobs in manufacturing industries where Minnesota already has a competitive advantage suggests that the greening of the economy could contribute to strengthening the state's manufacturing base.

Yet the greening of the manufacturing sector goes far beyond the manufacturing of green products. Perhaps the biggest contribution Manufacturing can play in Minnesota's transition to a carbon-neutral economy has to do with operational efficiencies capable of reducing waste and pollution from production processes. Concerns about rising production costs coupled with the desire to improve corporate image are turning several manufacturers into champions of waste-minimization practices, where green aligns with LEAN.[7]

The third industry generating multiple green job openings over the last two years was Wholesale Trade, which contributes to both Energy Efficiency, through plumbing and HVAC wholesalers, and to Pollution Prevention, through recyclable materials wholesalers.

The fourth industry, Other Services Except Public Administration, includes nonprofit organizations committed to protecting the environment and raising public awareness of environmental issues such as climate change. Another

[5] The LEED (Leadership in Energy and Environmental Design) AP credential provides a standard for professionals participating in the design and construction phases of high-performance, healthful, durable, affordable, and environmentally sound buildings. (Source: www.usgbc.org)

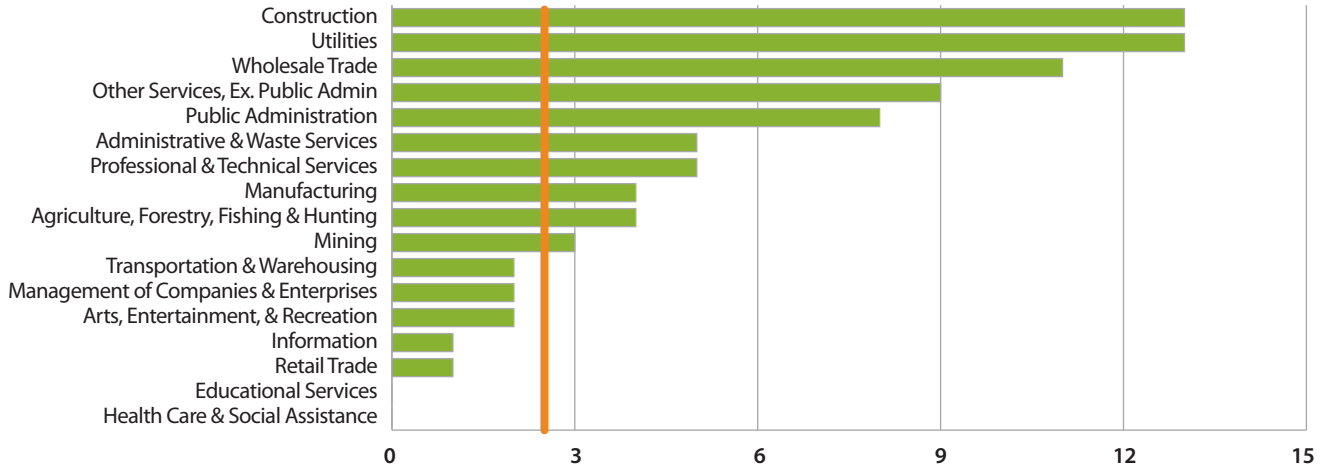
[6] Minnesota boasts a higher-than-average concentration of employment in the windows and glass manufacturing industries.

[7] LEAN is a production practice that aims at the creation and maintenance of a production system which runs efficiently, optimizing the use of time and resources (raw materials, equipment, labor) and reducing waste throughout the production process.

FIGURE 7

Share of Green Vacancies to all Vacancies within Industries

Source: Green addendum to MN JVS, 2009-2011



key industry for the advancement of green practices and technologies is Professional and Technical Services, delivered as engineering, environmental consulting, and laboratory testing services. The sixth industry, Public Administration, includes the administration of conservation programs. Finally, Administrative and Waste Services contribute to Pollution Control primarily through remediation services.

Not surprisingly, industries that did not report any green vacancies were Financial Services, Real Estate and Rental and Leasing, and Accommodation and Food Services.

When green vacancies are analyzed as a share of vacancies within each industry the results are very similar. As Figure 7 shows, the estimated overall share of hiring for green jobs ranged from 0.1 percent in the Health Care and Social Assistance sector to 13.4 percent in the Construction sector. Also reporting a relatively high percentage of green jobs were Utilities (13.1 percent), Wholesale Trade (11.3 percent), Other Services (9.8 percent), and Public Administration (8.4 percent). The overall share of green vacancies to total vacancies statewide (2.5 percent) is marked by an orange line in the graph.

The only industry that shows a high concentration of green vacancies despite reporting very few of them is Utilities. Hiring in Utilities was sluggish during the study period; still, one out of ten positions reported were green.

Utilities are a key industry for the future of the green economy. Besides creating direct green jobs typically engaged in Energy Efficiency, they generate demand for products and services provided by other industries aimed at increasing energy efficiency and mitigating the environmental footprint of utility operations. As a highly regulated industry sector, Utilities have an incentive to meet and sometimes exceed standards and federal regulations, such as air quality standards and renewable energy quotas. When utilities opt for generating renewable energy from biomass or methane from landfills they create demand for crop/biomass products, co-generation systems design, and waste transportation services. They might also need to purchase precision instruments for the detection of pollution and the prevention of leakages and inefficiencies, as well as IT and engineering services for the deployment of "smart grid" technologies such as Advanced Metering Infrastructure devices. By creating demand for advanced products and services some utilities are spurring the adoption of new technology and practices.

Green Vacancies by Detailed Industry Group

Figure 8 lists the top 20 detailed industries by number of green job vacancies in Minnesota. Included are examples of the environmentally beneficial activities that take place within each industry.

FIGURE 8

Green Vacancies by Industry, Fall 2009-Spring 2011

Top 20 Green Industries by 4-digit NAICS codes and Detailed Sub-industries

NAICS Code	Industry Name and Detailed Sub-industries	Green Openings	Examples of Green Activities
2382	***Building Equipment Contractors*** • Residential and Non-residential Plumbing/ HVAC Contractors • Residential Electrical Contractors	418	• Installation and service of furnaces, air conditioners, electrical building control systems, and geothermal heat pumps; roofing and insulation services
8133	***Social Advocacy Organizations*** • Environment & Conservation Organizations	316	• Public education and advocacy on conservation and environmental protection
4239	***Miscellaneous Durable Goods Merchant Wholesalers*** • Recyclable Material Merchant Wholesalers	304	• Recycling of post-consumer goods
5413	***Architectural and Engineering Services*** • Engineering Services • Architectural Services • Testing Laboratories	296	• Air quality permitting, environmental compliance, and environmental testing services; sustainable architectural design and construction
4533	***Used Merchandise Stores***	245	• Sorting and selling used goods
9241	***Administration of Environmental Programs*** • Administration of Conservation Programs	165	• Oversight of water and soil conservation programs
8113	***Commercial Machinery Repair/Maintenance***	156	• Wind turbine installation and repair
3345	***Electronic Instrument Manufacturing*** • Automatic Environmental Controls Manufacturing • Other Measuring and Controlling Devices Manufacturing • Industrial Process Variable Instruments Manufacturing	100	• Electrical building control systems and programmable thermostats; industrial precision instruments to measure air pollution, treat water, and control water flow for conservation purposes; process variable instruments to achieve resource efficiency in industrial processes
9211	***Executive, Legislative and General Government*** • Cities' and Counties' Executive Offices	90	• Administration and oversight of water and wastewater facilities, mass transit, air/water/ waste programs
7121	***Museum, Parks, and Historical Sites*** • Nature Parks	80	• Forest conservation; natural areas' groundskeeping services
5511	***Management of Companies and Enterprises*** • Managing Offices	73	• Corporate Research and Development in renewable energy, green chemistry, and green transportation technologies; lean production process design and oversight
5416	***Management and Technical Consulting Services*** • Environmental Consulting Services	73	• Environmental assessment services, building commissioning services
3261	***Plastics Product Manufacturing*** • All Other Plastics Product Manufacturing • Plastics Pipe and Pipe Fitting Manufacturing	70	• Development and manufacturing of recycled-content plastic products, pipes for radiant floor heating, fuel cells, and semiconductors
5629	***Remediation and Other Waste Services*** • Remediation Services	66	• Emergency environmental response in case of hazardous spills
5621	***Waste Collection*** • Solid Waste Collection • Hazardous Waste Collection	61	• Collection and processing of recyclable material
2381	***Building Foundation/Exterior Contractors*** • Nonresidential Roofing Contractors	50	• Roofing and insulation services
4859	***Other Ground Passenger Transportation***	41	• Mass Transit Services
3219	***Other Wood Product Manufacturing*** • Wood Window and Door Manufacturing	40	• Energy-efficient windows manufacturing
4237	***Hardware and Plumbing Merchant Wholesalers*** • Plumbing Goods Merchant Wholesalers	40	• Sale of water treatment and purification products
3334	***Heating, Ventilation, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing*** • HVAC Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	37	• Manufacturing, installation, and repair of energy efficient HVAC and geothermal heat units

Green Vacancies by Firm Ownership and Size

Firms reporting green jobs did not differ from the total population of firms in terms of ownership characteristics. Green job vacancies were predominantly concentrated in privately owned establishments, accounting for 87 percent of hiring. Private nonprofits accounted for 12 percent of green hiring activity (see Figure 9).

Firm size statistics, however, show that the distribution of green vacancies across size classes differed markedly from the distribution of the total population of vacancies (Figure 10). While green job vacancies were most highly concentrated in establishments with fewer than 50 employees (67 percent) and least concentrated in large-sized establishments (11 percent), total vacancies were most concentrated in medium-sized establishments (36 percent).

This finding is not surprising considering the types of establishments most likely to generate multiple green job openings: small nonprofits, watershed districts, regional offices of the National Park Service, recyclable materials merchant wholesalers, organic produce growers, plumbing contractors, wind turbine service companies, and Research and Development start-ups.

Total vacancies, in contrast, are more skewed towards medium and large-sized firms. This is primarily due to the high volume of vacancies reported in large health care and social assistance establishments. Health care is a fast growing industry with high turnover and a high share of total job vacancies, but jobs in this industry rarely meet the definition of a green job.

Why are the smallest businesses generating such a relatively high share of green jobs (29 percent) when they represent only 11 percent of employment statewide? The disproportionately high representation of firms with fewer than 10 employees suggests that green products and/or services can be a source of competitive strength for small companies, offering the opportunity to develop a niche position protected from bigger competitors.

This specific group of companies is also of particular interest because two-thirds of their green vacancies were newly created positions.[8]

Since the share of newly created positions compared to replacement openings decreases with firm size, it is reasonable to expect that green workforce growth will most likely occur in establishments with fewer than 50 employees. This finding is also consistent with the theory that small firms are in general more innovative and dynamic, therefore more likely to generate growth openings for both green and non-green activities.

FIGURE 9

Job Vacancies by Ownership

Fall 2009-Spring 2011

Ownership Type	Total Vacancies	Green Vacancies
Private Corporation	74%	75%
Private Nonprofit	14%	12%
Total Private Ownership	**88%**	**87%**
Government Ownership	**12%**	**13%**
Total, All Ownerships	**100%**	**100%**

FIGURE 10

Job Vacancies by Firm Size

Fall 2009-Spring 2011

Firm Size Class	Total Vacancies	Green Vacancies	Green Vacancies as a Share of Total Vacancies
1-9 employees (very small)	12%	29%	5.9%
10-49 employees (small)	27%	37%	3.4%
50-249 employees (medium)	36%	22%	1.6%
250 or more employees (large)	25%	11%	1.0%
Total, All Size Classes	**100%**	**100%**	**2.5%**

[8] Newly created positions are defined as positions new to the company, not replacement openings to fill positions recently left vacant.

5 GREEN VACANCIES BY OCCUPATION

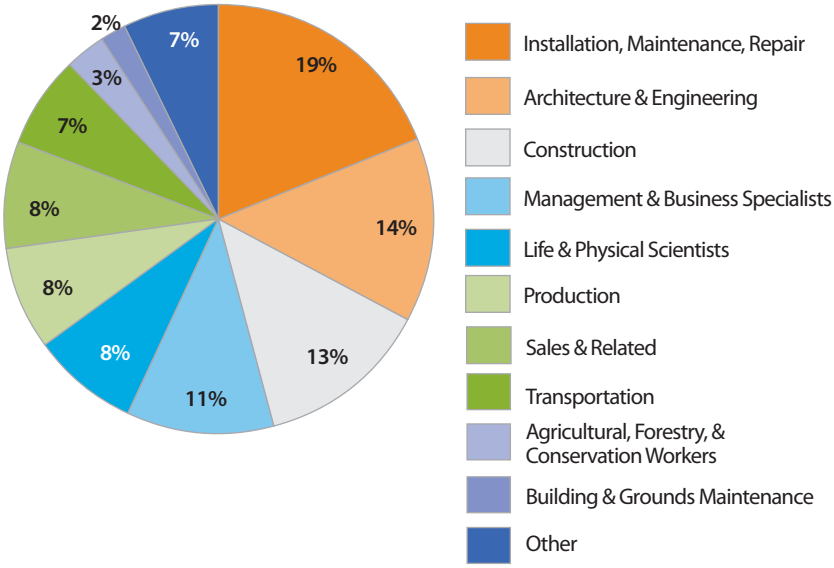
The greening of Minnesota's economy is most clearly observable at the occupational level where new green tasks are being added to traditional occupational tasks. When green-related tasks, often in the form of a practice or project,[9] become more than simply occasional and begin to require additional and/or unique preparation, green jobs start differentiating themselves from non-green jobs within the same occupation. Through meticulous work, green-related tasks were captured one job vacancy at a time in order to identify potential shifts in workforce competencies as the amount of time dedicated to these tasks increases.

[9] The project-driven nature of some green activities is also one of the reasons why green jobs are so hard to identify and so dynamic in nature. An architect can work on a LEED-certified project today and on a traditional construction project tomorrow.

FIGURE 11

Green Vacancies by Occupational Group

Source: Green addendum to MN JVS, 2009-2011



Green Vacancies by Broad Occupational Group

Recent hiring for green jobs has been dispersed across 150 occupations with nearly half concentrated in three major occupational groups: Installation, Maintenance, and Repair; Architecture and Engineering; and Construction. (See Figure 11)

Installation, Maintenance, and Repair

Repair and maintenance services are needed everywhere in the green economy, but predominantly they contribute to energy efficiency by operating, installing, replacing, and fixing systems such as furnaces, boilers, HVAC systems, and factory equipment to optimize their use. Even the most energy efficient building or equipment can rapidly lose its operative efficiency unless properly maintained and monitored.

Green task examples are:

- Install and fine-tune HVAC and building control systems for energy efficiency;
- Monitor energy savings and track energy consumption in Facilities Management Systems (FMS) to ensure continuous energy efficiency gains;
- Maintain green equipment such as geothermal heat units and methane boilers;
- Repair and operate heavy equipment to processes municipal waste for use in energy generation;
- Ensure proper functioning of wind turbines.

As shown in Figure 12, the occupations where most green vacancies were found during the study period are projected to grow over the next eight years.

FIGURE 12

Installation, Maintenance, and Repair Occupations with the Most Green Vacancies by Standard Occupational Classification

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
499021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	$24.35	16.2%	Postsecondary vocational training
499081	Wind turbine technician (NEW code)	NA	NA	NA
491011	First-Line Supervisors/Managers of Mechanics, Installers, and Repairers	$28.95	0.6%	Work experience in related occupation
499041	Industrial Machinery Mechanics	$22.21	8.0%	Long-term on-the-job training (> 12 months)
499071	Maintenance and Repair Workers, General	$18.58	11.1%	Moderate-term on-the-job training

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

Architecture and Engineering

Both in terms of hiring demand and range of roles they are asked to play, engineers are the backbone of the green economy in Minnesota. Where there is new technology there are engineering issues about how to incorporate it in designs to ensure manufacturability, quality, and performance, ultimately determining product adoption in the marketplace. Engineers can assume roles as varied as identifying innovative solutions to one-of-a kind technical problems and educating the customer about the long-term environmental benefits of such solutions. Finally, engineers are increasingly invited to the table early in a green project, as in the case of a mechanical engineer whose role in a construction/retrofit project starts with the initial design stage and extends after the life of the building.

Green tasks examples are:

- Incorporate emission control technologies or hybrid/battery systems in vehicles;
- Design green infrastructures, defined as technologies and practices that use natural systems to provide utility services while protecting sensitive waters. Examples are water supply and stormwater management infrastructures;
- Prepare environmental assessments of properties to check for contamination and identify what it would take to clean it up;
- Design and implement lean production processes;
- Design for manufacturability of a new green product.

Architecture and engineering occupations are likely to experience a gradual shift in workforce competencies because of the greening of the economy. In fact, this occupational group is more likely than others to need additional on-the-job training or certification to work on green-related projects. Examples of emerging green certifications are Leadership in Energy and Environmental Design (LEED) and Certified Energy Manager (CEM).

See Figure 13 for wage, job growth, and educational requirements of these occupations.

FIGURE 13

Architecture and Engineering Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
172081	Environmental Engineers	$38.25	17.7%	Bachelor's degree
172141	Mechanical Engineers	$36.05	-0.3%	Bachelor's degree
172071	Electrical Engineers	$39.85	-1.3%	Bachelor's degree
172041	Chemical Engineers	$36.85	-8.9%	Bachelor's degree
172112	Industrial Engineers	$36.88	11.9%	Bachelor's degree
173025	Environmental Engineering Technicians	$20.86	16.6%	Associate degree
171011	Architects, Except Landscape and Naval	$35.55	11.5%	Bachelor's degree
173013	Mechanical Drafters	$23.87	-7.4%	Postsecondary vocational training

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

Construction

Several construction occupations might see increased hiring as demand for energy efficiency and infrastructure construction services grows, such as construction of light rail transit lines or electrical power lines connecting wind turbines to the power grid.

Green tasks examples:

- Install insulation and other energy-efficient features, choosing the appropriate construction materials to enhance efficiency gains;
- Install electrical wiring for geothermal heat systems, energy-efficient HVAC equipment, and lighting systems;
- Cleanup, handle, and move hazardous materials.

Green tasks for construction workers typically do not require any enhanced skills beyond foundational skilled trade competencies. In other words, there may very well be an increase in the amount of time dedicated to green tasks, but it is unlikely to change the nature of the work.

As illustrated in Figure 14, the occupations that generated the highest number of green vacancies from fall 2009 to spring 2011 are all projected to grow over the next eight years.

Management and Business Specialists

This occupational group is critically important for the future of the green economy because of the role it plays in market creation, customer education, organizational development, and regulatory compliance. The impetus for the greening of a firm often starts at the top, either from visionary leaders who see in green products/services an opportunity to improve the firm's environmental standing, or from centralized business functions that champion the cultural and organizational changes inherent in a sustainability agenda.[10] Corporate-level goals can vary widely, from voluntarily becoming more energy-efficient to staying in compliance with stricter environmental regulations.

Green tasks examples are:

- Analyze demand and customer requirements for new product development in emerging green markets;
- Engage in business development and commercialization of new green products and technologies;
- Develop and promote corporate sustainability planning and reporting;
- Apply environmental cost accounting;
- Implement a regulatory strategy for the company to comply with rules in all environmental areas (air, water, waste, hazardous materials, transportation);
- Oversee governmental restoration programs for prairies, wetlands, and forests, including legislative strategy and policy development;
- Oversee chemical/toxicological analysis and regulatory reviews of raw materials to ensure they are in compliance with safety and environmental regulations;
- Train other employees in waste minimization practices such as LEAN.

FIGURE 14

Construction Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
472181	Roofers	26.20	9.8%	Postsecondary vocational training
472111	Electricians	29.88	5.9%	Long-term on-the-job training (> 12 months)
474041	Hazardous Materials Removal Workers	28.57	4.3%	Moderate-term on-the-job training (1-12 months)
472152	Plumbers, Pipefitters, and Steamfitters	29.89	11.9%	Long-term on-the-job training (> 12 months)
471011	First-Line Supervisors/Managers of Construction Trades and Extraction Workers	30.60	14.9%	Work experience (in related occupation)

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

[10] Green is fundamentally about improved environmental attributes of products and services, while sustainability embraces economic and social elements. Sustainability means ensuring that all future citizens have the opportunity to enjoy lives as rich and meaningful as our own, and in a natural environment that is at least as clean, intact, and healthy as that which we enjoy today (sustainability definition used by the Minnesota 2050 Project and the Minnesota Statewide Conservation and Preservation Plan, 2008).

Business operations specialists have the highest concentration of new green job titles, often reflecting the emergence of new green subspecialties such as:

- Regulatory Affairs Managers
- Environmental Compliance Managers
- Lean Supply Chain Managers and/or Logistics Analysts
- Green Marketers
- Wind Energy Project Managers
- Remediation Project Managers
- Energy Auditors
- Sustainability Specialists
- Water Resource Specialists

These sub-specialties, identified by O*NET[11] as "New and Emerging Green Occupations," do not fit very well in the existing Standard Occupational Classification taxonomy. Therefore, they are captured in the residual categories "Managers, All Other" and "Business Operations Specialists, All Other" (see Figure 15).

Life and Physical Scientists

All sectors of the green economy need scientists, not only to conduct laboratory research but to get it out of R&D and into production. Furthermore, life and physical scientists are brought on board to assist engineers, architects, construction managers, and technicians with the aim of incorporating ecological concepts into the built environment, landscape design, and remediation design. The shift in emphasis from end-of-pipe treatment methods to prevention of environmental problems and "green remediation" technologies further increases hiring demand for people with science degrees and related experience. They participate in projects as varied as construction, remediation, civil engineering, and land management to ensure that all of the natural resources involved are treated sensitively.

An emerging area of activity for life scientists is the "green product certification" process through eco-toxicological and/or regulatory reviews. These activities are essential to the scale-up and commercialization of innovative green products.

Green tasks examples:

- Conduct scientific characterization of natural resources (soil, underground water);
- Conduct laboratory tests for contamination and pollution in water and air samples;
- Evaluate product ingredients for long-term sustainability advantages in the market;
- Establish regulatory strategies for new product approval and identify analytical tests that need to be conducted to obtain such approval (for example, testing in compliance with the Environmental Protection Agency).

FIGURE 15

Management and Business Specialists Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
112021	Marketing Managers	$55.58	8.6%	Work experience, plus bachelor's or higher degree
113071	Transportation, Storage, and Distribution Managers	$38.78	-8.1%	Work experience in related occupation
119041	Architectural and Engineering Managers	$56.02	-1.6%	Work experience, plus bachelor's or higher degree
119199	Managers, All Other	$47.72	7.0%	Work experience in related occupation
119121	Natural Sciences Managers	$51.73	11.3%	Work experience, plus bachelor's or higher degree
131199	Business Operations Specialists, All Other	$25.17	8.0%	Bachelor's degree

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

[11] The Occupational Information Network (O*NET), a program of the U.S. Employment and Training Administration, is an online database intended to contain all the jobs that exist in the United States. The O*NET occupational taxonomy is compatible with the SOC taxonomy but it is more comprehensive, identifying and describing over 950 occupations. To access O*NET information on the green economy see http://www.onetcenter.org/green.html?p=2

Figure 16 indicates the occupations where most green vacancies were found, and shows their excellent long-term employment outlook.

Production

Only a very small number of production occupations met the study's definition of green jobs. This finding, seemingly in contradiction with industry findings that identified manufacturing as a major source of green hiring activity, is explained by the fact that production jobs make up a smaller share of employment in the manufacturing sectors where green jobs are most likely to be found. Advanced manufacturing, for instance, is also likely to employ a higher percentage of engineers and a lower percentage of production-floor jobs compared to less advanced manufacturing industries. For example, engineers make up 21 percent and production occupations make up 30 percent of employment in electronic instrument manufacturing. This pattern is also related to the use of automated production equipment that substitutes labor and to the intensity of technology embedded in the products.

Besides being employed in manufacturing, some green production jobs are found in other industries such as large utility plants, hospitals, and building facilities.

FIGURE 16

Life and Physical Science Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
191031	Conservation Scientists	$27.88	6.8%	Bachelor's degree
192041	Environmental Scientists and Specialists, Including Health	$27.24	15.4%	Master's degree
192031	Chemists	$33.95	3.9%	Bachelor's degree
194091	Environmental Science and Protection Technicians, Including Health	$20.20	27.0%	Associate degree
194093	Forest and Conservation Technicians	$16.19	5.8%	Associate degree
192042	Geoscientists, Except Hydrologists and Geographers	$32.99	17.9%	Master's degree
192043	Hydrologists	$32.48	5.4%	Master's degree
191013	Soil and Plant Scientists	$29.50	3.1%	Bachelor's degree
194021	Biological Technicians	$21.93	20.3%	Bachelor's degree
191023	Zoologists and Wildlife Biologists	$25.91	3.7%	Bachelor's degree

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

FIGURE 17

Production Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
511011	First-Line Supervisors/Managers of Production and Operating Workers	$25.40	-5.1%	Work experience in related occupation
519399	Production Workers, All Other	$13.24	-0.3%	Moderate-term on-the-job training (1-12 months)
512099	Assemblers and Fabricators, All Other	$12.81	6.4%	Moderate-term on-the-job training (1-12 months)
518021	Stationary Engineers and Boiler Operators	$26.15	8.7%	Long-term on-the-job training (> 12 months)
518031	Water and Liquid Waste Treatment Plant and System Operators	$22.58	14.5%	Long-term on-the-job training (> 12 months)

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

Green tasks examples include:

- Separate recyclable from non-recyclable material in a recycling plant;
- Operate and troubleshoot machines predominantly used to make green products, for example water filtration membranes;
- Monitor and operate machinery and pumps in municipal wastewater treatment facilities;
- Operate and ensure efficient use of boilers.

Since green tasks for production workers are, for the most part, traditional tasks that happen to be essential to a green product, neither work content nor occupational competencies are likely to change over time as an effect of the greening of the economy. See Figure 17 for a list of these occupations.

Sales and Related

Sales occupations meet the definition of green job only if directly engaged in the promotion, sale, or commercialization of a green product/service. With their innovative and often technical nature, the sale of many green products requires specialized knowledge in order to demonstrate the product's benefits to the customer and to obtain constant feedback on product uses and areas of improvement. The occupation most commonly engaged in consultative sales for technical products are technical sales representatives.

Green tasks examples include the following:

- Identify and develop new business opportunities within assigned accounts and develop business relationships;
- Determine prices of merchandise and assist customers in re-sale store;
- Solicit contributions and educate people about environmental issues such as clean water.

Figure 18 indicates the occupations where most vacancies were found.

Transportation

Green jobs in transportation are very rare, because merely transporting a green product is not a green activity.

Green tasks examples include the following:

- Collect recyclable materials from residential homes and transport them for recycling to a material recovery facility;
- Drive a public bus (not including school buses) or passenger train.

Figure 19 displays these occupations.

FIGURE 18

Sales and Related Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
414011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	$39.27	2.9%	Work experience (in related occupation)
411011	First-Line Supervisors/Managers of Retail Sales Workers	$15.89	4.5%	Work experience in related occupation
419099	Sales and related Workers, All Other	$21.19	4.6%	Moderate-term on-the-job training (1-12 months)

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

FIGURE 19

Transportation Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
533021	Bus Drivers, Transit and Intercity	$15.34	5.5%	Moderate-term on-the-job training (1-12 months)
537081	Refuse and Recyclable Material Collectors	$16.76	26.4%	Short-term on-the-job training

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

Agricultural, Forestry, and Conservation

These are predominantly government forest service jobs and farmers/growers committed to organic and sustainable practices. Since most people employed in these occupations have always performed green tasks, they will not experience a transformation in competencies as an effect of the greening of the economy.

Green tasks examples include:

- Planting, harvesting, and packing organic produce;
- Oversee the implementation of government programs to conserve, protect, and enhance fish, wildlife, and plants and their habitats;
- Supervise foresters and enforce Minnesota statutes surrounding forestry resource management.

Figure 20 displays these occupations.

Building and Grounds Maintenance

Green jobs in this occupational group primarily perform manual labor to protect the natural environment (see Figure 21). Groundskeeping work performed for predominantly aesthetic purposes, like growing flowers and non-native plants or maintaining golf-turf grass, or through the use of harmful pesticides, does not qualify as environmentally beneficial.

Green tasks examples include:

- Forestry restoration work such as tree planting, seeding, erosion control methods, brush cutting, prescribed burns;
- Prairie restoration work including mapping and assessing invasive species, applying herbicides, implementing biological control programs, maintaining mowers and other equipment.

FIGURE 20

Agricultural, Forestry, and Conservation Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
454011	Forest and Conservation Workers	$11.65	NA	Moderate-term on-the-job training (1-12 months)
452092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	$10.99	5.9%	Not Available
452099	Agricultural Workers, All Other	$11.25	11.2%	Not Available

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

FIGURE 21

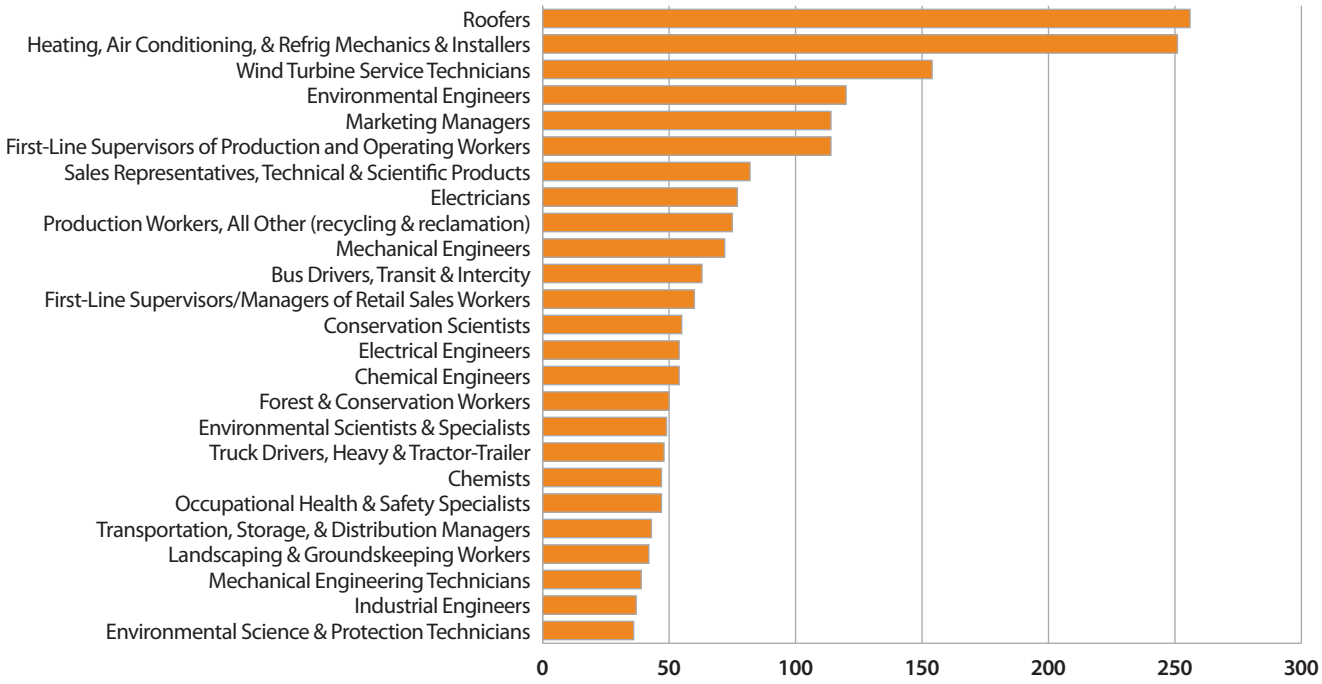
Building and Grounds Maintenance Occupations with the Most Green Vacancies

SOC Code	SOC Title	Median Hourly Wage*	Projected Growth**	Most Common Level of Education***
373011	Landscaping and Groundskeeping Workers	$12.36	15.3%	Short-term on-the-job training
371012	First-Line Supervisors/Managers of Landscaping, Lawn Service, and Groundskeeping Workers	$22.41	18.7%	Work experience in related occupation

**Source: Occupational Employment Statistics Survey, Fourth Quarter 2010*
*** Source: Long-term Employment projections, 2009-2019*
****Source: BLS Employment Projections, 11 Educational Category System*

FIGURE 22

Green Vacancies for Top 25 Occupations



Green Vacancies by Detailed Occupation

Figure 22 lists occupations that produced the most green job openings, aggregating results from four survey rounds. These occupations alone accounted for 52 percent of estimated green job vacancies in Minnesota.

Green activities are an integral part of work performed in occupations like wind turbine technicians, environmental engineers, conservation scientists, forest and conservation workers, and environmental science and protection technicians. The majority of jobs in these occupations are green. On the other hand, occupations like marketing managers and mechanical engineers include workers who, for the most part, do not meet the conservative definition of a green job adopted in this study either because they do not perform green tasks or do not perform them full time. In these occupations, greenness is often a transitional characteristic that depends on how much time happens to be spent on a specific project, product, or service. This is one of the reasons why green jobs are so hard to measure and so dynamic in nature.

6 WAGES OF GREEN VACANCIES

Many commentators have suggested that green jobs are "good jobs," implying, in particular, higher pay, but also more economic stability compared to non-green jobs. The purpose of this chapter is to shed some light on the accuracy of these claims.

To what extent are green jobs "good jobs"? To answer the question fully we would need to compare green to non-green jobs of similar education level within the same occupation and industry, while also taking into account factors such as career advancement opportunities, access to healthcare, and flexibility in work schedules. Data limitations do not allow a comparison of the full range of job quality indicators. Nevertheless, vacancy data can help determine whether some categories of green jobs provide higher wages and more stable employment status for workers compared to similar non-green jobs.

Comparing Green Job Vacancy Wages and Total Vacancy Wages

In order to quantify the earning potential of green jobs, the analysis that follows compares wage offers in green vacancies to wage offers in the total population of vacancies. Before interpreting the results, it is important to note that vacancy wages represent *minimum*[12] wage offers that are subject to negotiation between candidates and employers. Initial wage offers typically are lower than wages paid to incumbent workers.

[12] In cases when employers indicated a wage range, the lowest value of the range was chosen as the basis for the vacancies' median calculation for both green and non-green vacancies.

As shown in Figure 23, the wage distribution for green job vacancies shows higher hourly pay rates than total vacancies. When considering only full-time vacancies, green wages again appear to be higher with the only exception in the top 10 percent of the distribution (90th percentile) where green vacancies offer $34 hourly compared to $40 for all vacancies. These results show the competitiveness of green vacancies wages in relationship to total vacancies wages.

Are these results enough to confirm the existence of a "green wage premium"? Certainly not, as other factors play a role. Higher wages in green jobs can result from their specific occupational composition, or from higher wages being paid in the industries where green firms are more concentrated. Furthermore, higher wages can be a function of the additional skills, knowledge, or experience that the positions require.

FIGURE 23

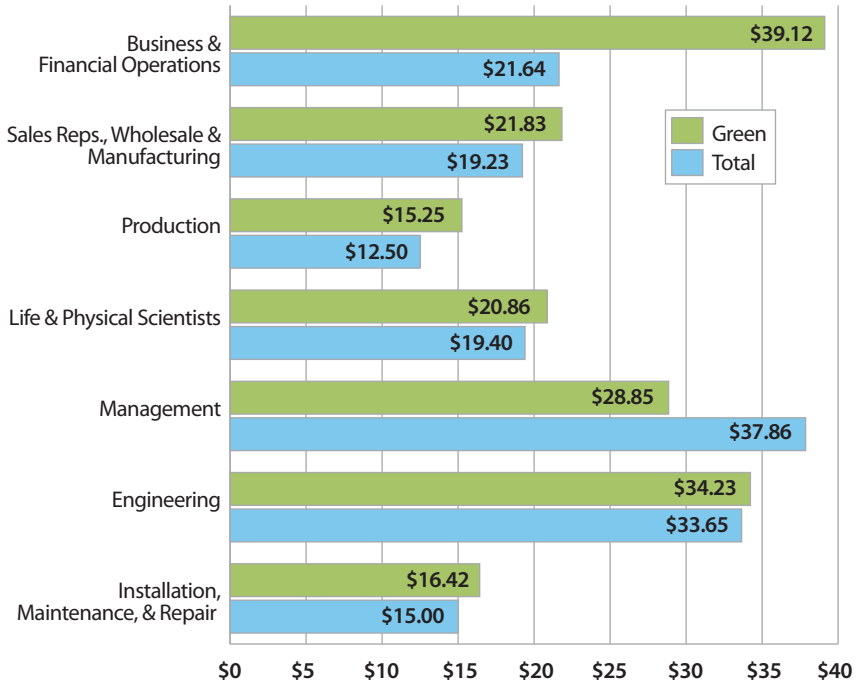
Hourly Wage Percentiles Comparisons

Green Vacancies and Total Vacancies — Minnesota, Fall 2009-Spring 2011

	10th pct	25th pct	Median	75th pct	90th pct
Green Vacancies (both full-time and part-time)	$ 8.00	$ 10.34	$ 16.42	$ 25.22	$ 34.23
Green Vacancies (only full-time)	$ 9.00	$ 12.85	$ 19.56	$ 27.95	$ 34.53
Total Vacancies (both full-time and part-time)	$ 7.25	$ 8.00	$ 10.75	$ 17.00	$ 32.70
Total Vacancies (only full-time)	$ 8.25	$ 10.00	$ 14.42	$ 21.97	$ 40.87

FIGURE 24

Median Hourly Wages for Full-time Vacancies, Selected Occupational Groups



Green Wages by Occupation

Given the type of work that green jobs involve, it was not surprising to find relatively higher concentrations of green jobs in better paying occupations such as business specialists and engineers. As described in the previous chapter, green vacancies were less likely to be found in transportation, agriculture, office and administrative support, and protective service occupations, all of which are also relatively low-paid.

In order to investigate if the higher wages observed in green vacancies are a function of their occupation, Figure 24 compares median wage offers for green vacancies to those for total vacancies in selected groups of occupations[13] where hiring for green jobs was most concentrated: Installation, Maintenance, and Repair; Engineering; Construction; Management; Life and Physical Science Occupations; Production; Sales Representatives; and Business and Financial Operations Occupations.

[13] Unfortunately, the survey sample size does not allow for comparisons at the detailed occupational level.

Wage offers in green vacancies appear slightly more competitive than total wage offers within the same group with only two notable exceptions:

- Wage offers for green jobs were much higher than total wage offers in Business and Financial Operations occupations. This is because green business operations specialties often require enhanced skills/expertise to perform green tasks, as highlighted in the previous chapter. Examples of occupations where emerging green specialties appeared to be better paid than others within the same occupation are compliance officers, cost estimators, and marketing specialists. Some employers reported difficulties filling these types of positions.
- Wage offers for green jobs were $9 lower than total wage offers in Management occupations. This result is possibly driven by the fact that over a third of green vacancies in management originated from non-profit organizations where the pay is lower than in private corporations.[14] In other words, the most highly paid CEOs and managers are more likely to be non-green than green.

From this analysis it appears clear that the observed wage differences between green and total vacancies are primarily driven by occupational differences. Within the same occupational category, the "greenness" of the position might drive higher wages if employers start requiring specialized skills, knowledge, education, and/or experience to perform green tasks. For example, green jobs in emerging niche industries, just like any jobs in emerging industries, might require experience and a network of contacts that is hard to find in the current workforce. Also, the green economy might hold a higher ratio of newer and still developing technologies compared to non-green sectors, requiring a step-up in competencies and corresponding higher wage offers.

FIGURE 25

Job Vacancies Status and Seasonality

Fall 2009-Spring 2011

	Total Vacancies	Green Vacancies
Full-time	60%	89%
Part-time[16]	40%	11%
Permanent	80%	79%
Temporary/Seasonal	20%	21%

Other Attractive Characteristics of Green Jobs

Other important dimensions of job quality captured in this study besides wages are health care coverage and job stability.[15] As Figure 25 summarizes, almost nine out of 10 green vacancies were full-time. In contrast, only 60 percent of total vacancies were for full-time work.

Moreover, 64 percent of green jobs offered health insurance benefits, another indicator of job quality. Full-time green jobs were much more likely to offer health care benefits than part-time green jobs. Among full time green vacancies, 70 percent had health care coverage compared to 18 percent among part-time vacancies.

Interestingly, green vacancies did not differ at all from the total population of vacancies with regards to seasonality: 80 percent of all reported positions were permanent. The incidence of seasonal work in the Minnesota economy, with observed spikes in the spring when the weather warms up, affects green job vacancies as much as it affects the overall population of vacancies.

The analysis of wage and work status in green vacancies demonstrates that the Minnesota green economy is capable of producing high-quality job opportunities by driving demand for full-time jobs predominantly in higher paid occupations. Green jobs may not be many, but they have desirable characteristics.

Besides job quality, an important consideration for jobseekers and/or students deciding whether they should pursue a green career is the transferability of their education credentials and skills into a green industry or occupation. The following chapters are dedicated to exploring education, experience, and skills characteristics of green vacancies.

[14] This finding also explains why green wages overall were lower than total vacancy wages only at the 90th percentile of the wage distribution.

[15] The study does not aim at capturing other dimensions of job quality such as career advancement opportunities, flexibility of schedules, family friendly policies, etc.

[16] Part-time is defined as fewer than 35 hours per week.

7 EDUCATION CHARACTERISTICS OF GREEN VACANCIES

A necessary requirement for a successful green economy is the availability of a well-qualified workforce. This chapter explores qualification requirements in green vacancies to help students and career seekers prepare for in-demand green careers.

Education Requirements in Green Job Vacancies

As illustrated in Figure 26, about 63 percent of green vacancies required some level of education beyond a high school diploma. This contrasts with economy-wide findings in which only 40 percent of vacancies required a comparable level of education or training.

Bachelors and vocational degrees, a prerequisite for employment in 32 percent and 22 percent of surveyed cases respectively, were most useful for jobseekers applying for green jobs.

FIGURE 26

Educational Characteristics of Green Vacancies

Fall 2009 – Spring 2011

Education Categories	Total Vacancies	Green Vacancies
H.S./GED degree or less	51%	37%
Vocational degree	9%	22%
Associate degree	6%	6.3%
Bachelor's degree	20%	32%
Advanced degree	5%	2.5%
No response	8%	0.2%

FIGURE 27

Majors Most Commonly Cited as Prerequisite for Employment in Green Vacancies

Fall 2009 – Spring 2011

Majors	Frequency of Mention	Selected Subspecialties
Engineering	44%	Environmental, civil, mechanical, electrical, chemical, and industrial engineering; quality engineering
Science	42%	Chemistry, geology/geochemistry, hydrology, conservation biology, environmental science, materials science, ecology, water resources, forest science
Business/Marketing	12%	Sales, Marketing, Communications, Business Administration (preferably MBA), Operations (especially supply chain and logistics), LEAN manufacturing management
Architecture/Design	3%	Architecture, landscape architecture, mechanical or computer-aided design
IT (Computer Science)	2%	Management Information Systems, computer software engineering
Health and safety	2%	Occupational safety
Economics/Finance	1%	Resource economics, accounting
Natural resource management	1%	Environmental/natural resource management, fisheries and wildlife management, forestry management
No specific major, any field	7%	

Degrees in engineering (chemical, mechanical, civil or environmental), chemistry, environmental science, and vocational training in HVAC repair and maintenance were among the credentials preferred by respondents (see Figure 27).

Fourteen percent of data with valid responses indicated engineering and science majors as equally qualifying for work. A combination of engineering and chemistry was common.

Overall, results demonstrate that green firms pull a lot of their talent from science, technology, engineering, and mathematics (STEM)-related programs. STEM areas are foundational for green jobs, not only because STEM occupations are relatively more likely to be impacted by greening trends,[17] but because green jobs overall tend to require a higher degree of technical and quantitative skills. An important implication of this finding is that higher education institutions, as well as vocational trade schools, will have an important role to play in building the local talent businesses need to compete in the green economy. Furthermore, strengthening STEM education from the K-12 to postsecondary level is crucial to prepare the future workforce for work in green economy sectors.

Green jobs in Minnesota also seem to require slightly more experience than the overall population of vacancies. Figure 28 shows that 69 percent of green vacancies required some kind of work experience, especially experience related to the position.

FIGURE 28

Green Vacancies by Experience Level

Fall 2009 – Spring 2011

Experience Levels	Total Vacancies	Green Vacancies
No experience	26%	30%
Work experience, either general or related to the position	65%	69%
No response	9%	1%
Total	100%	100%

Among the most commonly cited experience requirements were project management, HVAC and refrigeration, EHS (management of the Environmental Health and Safety functions), product development, and product commercialization. Industry-specific work experience was also mentioned as important, especially in emerging industries

[17] Almost one-third of green vacancies were in STEM occupations.

FIGURE 29

Most Frequently Mentioned Licensing and Certification Requirements in Green Vacancies

Fall 2009 – Spring 2011

	Percent of Total Green Vacancies with Valid Responses	Most Commonly Requested Certifications and Licenses
Requiring a certification	15%	Wastewater Operator certification, CFC Refrigerant Transition and Recovery certification[18], NATE (North American Technician Excellence) HVACR certification[19], 40-hours OSHA Hazardous Materials Training certification, EIT (Engineer In Training) certification, Project Management Professional (PMP) certification
Preferring a certification	3%	OSHA Hazardous Materials Training certification, Certified Energy Manager (CEM), Leadership in Energy and Environmental Design (LEED) AP, Six Sigma
Requiring a license	11%	Commercial Drivers' License, Professional Engineer License, Boiler Operator License
Information not available	3%	

such as renewable energy (wind, solar, geothermal) and the energy savings industry. Interestingly, utilities were among the most frequently cited industries where significant work experience could be gained, demonstrating the importance of utilities as customers of green products and services.

Licensing and Certification Requirements in Green Vacancies

Figure 29 illustrates that 15 percent of reported green vacancies needed a certification while 11 percent needed a license. The types of licenses most commonly required in green vacancies directly mirror their occupational classification. For example, transit bus drivers and forestry workers clearly require a commercial drivers' license, and engineers working on government contracts in the field of remediation or municipal infrastructure development require a Professional Engineer license.

Certifications that exclusively measured the ability to perform green-related work were not among those most frequently mentioned by employers as prerequisite for employment. Since greenness is still predominantly an add-on to existing jobs, green jobs share the same training path as their non-green counterparts, including the same certification requirements. For example, project managers working on green projects might require a Project Management Professional Certification which is not a green certification per se. The reality is that green economy sectors are not yet defined enough to lead to industry-recognized credentials that would allow applicants to demonstrate their command of the skills and knowledge necessary to function in these specializations.

The only inherently green certifications mentioned by a large enough number of employers were Wastewater Operator certification, CFC Refrigerant Transition and Recovery certification, OSHA Hazardous Materials Training Certification, Leadership in Energy and Environmental Design (LEED), and Certified Energy Manager (CEM) certification. LEED and CEM are definitely the most interesting to watch because they are not occupation-specific, they are customer-driven rather than government-mandated, and they cover a wide range of skills and knowledge areas relevant to the green economy. If they gain recognition as employee training tools they could have a substantial effect on demand for workers with specialized green knowledge and expertise.

[18] HVAC technicians need to take a Chlorofluorocarbon (CFC) Refrigerant Recycling Training to limit release of ozone depleting substances. The course is approved by the Environmental Protection Agency per the requirements of Section 608 of the Clean Air Act.

[19] North American Technician Excellence (NATE) is a certification body for heating, ventilation, air conditioning and refrigeration technicians. Specialties include Air Conditioning, Air Distribution, Heat Pumps, Gas Furnaces, Oil Furnaces, Commercial Refrigeration, and Senior HVAC Efficiency Analyst.

8 SKILLS, KNOWLEDGE REQUIREMENTS, AND WORKFORCE GAPS IN GREEN VACANCIES

One of the most innovative aspects of this study is the measurement of skill and knowledge requirements in green jobs. The purpose of the in-depth telephone survey was to capture skills that are transferable across green and non-green sectors, as well as specialized knowledge unique to green jobs. Both pieces of information are critical for career decision-making. On the one hand, acquiring transferable skills early in one's career opens the door to occupational mobility, with green jobs being a possible area of future employment growth. On the other hand, acquiring specialized green knowledge can be a source of competitive advantage in the job market. Information on skills and knowledge is also critical for educational institutions to develop curricula that best align with local employers' needs.

Skill Requirements in Green Vacancies

Right from the beginning of data collection, when the research team conducted cognitive testing on survey questions, it became clear that employers do not recognize skills as being green or not green. In other words, green jobs do not require new, green skills. Instead, they typically require an existing skill to be used more frequently or at a more advanced level. For instance, math skills may be used at a more advanced level for green jobs than for their non-green counterparts.

Respondents were asked which of the following skills or skill sets were necessary for the position: Supervisory, Project Management, Mathematics, Technical (including Technology Design), and Information Technology.[20] As illustrated in Figure 30, the greatest number of green positions required technical skills, followed by math skills.

Why are technical skills in such high demand? Technical skills cover a wide spectrum of activities (operating, monitoring, repairing, troubleshooting, quality control analysis, product design) that will become more critical to job performance because of the complex, technical nature of the environmental problems businesses and communities are starting to face. Among various technical skills, technology design is essential for developing new green products and finding gaps in performance between green and non-green products. It was cited as important in 13 percent of green vacancies, primarily engineers and scientists.

Although some green job vacancies did not require advanced math, most required at least basic quantitative skills to perform analytical or operational tasks. Examples of basic/intermediate math include: recording expenditures, preparing drawings and specifications, operating programmable logic control tools, and collecting/analyzing quantitative data (geospatial information, lab test results, biological survey results, etc.). Advanced math skills are needed for statistical analysis or scientific and engineering calculations.

Technical and mathematical skills combined were required in 48 percent of all green vacancies, indicating high demand for candidates who can blend the two skill sets.

Results displayed in Figure 30 suggest that the skills needed to transition into the green economy are to some extent already present in the current workforce, but skills in science, technology, engineering, and mathematics (STEM) areas are in higher demand than others for this group of jobs. This also implies that people who received STEM training or are currently employed in STEM-related occupations might be able to transfer to the green economy with minimal additional training.

FIGURE 30

Frequencies of Specific Skill Requirements in Green Job Vacancies

Fall 2009 – Spring 2011

	Percent Requiring the Skill	Examples of How the Skill is Applied in Practice
Technical	66%	Redesign a manufacturing process to reduce waste, use specialized tools to diagnose and repair wind turbines, perform skilled maintenance operations work involving water treatment and distribution systems
Mathematics	65%	Analyze emissions data for greenhouse gas inventories
Project Management	21%	Develop and implement land management plans for a small eco-region, convene public conservation partners, evaluate success of project in meeting conservation objectives
Supervising	20%	Lead, manage, schedule, and assign work for staff and subcontractors
Information Technology	2%	Develop software and hardware for HVAC or smart grid systems, program platform control systems for the water treatment industry

[20] These specific skills were selected for inclusion in the survey based on evidence gathered through cognitive testing of survey questions with a small sample of respondents. Three main factors guided the choice: the significance of a skill for a broad range of green jobs (survey questions could not be too occupation-specific); the applicability of a skill to a broad range of green and non-green jobs (foundational skill sets were preferred over narrowly defined skills in order to capture transferability across sectors); the ease with which respondents could interpret and respond to the questions over the phone in a short time (conceptual clarity and brevity of the survey).

The most in-demand skill area unrelated to STEM was Project Management, important in 21 percent of surveyed positions. Rather than one skill, Project Management is a skill set that encompasses budgeting, time management, communication, personnel management, and management of material resources. This particular set of skills is emerging as a prerequisite for green employment because many green activities come in the form of interdisciplinary projects, which require the skillful integration of technical and managerial roles. A good example is a LEED-certified construction project.

In combination with hard skills, green employers are seeking workers with the following soft skills:

Learning: Since green technologies evolve rapidly, employers are seeking motivated life-long learners capable of continuously acquiring and applying new knowledge.

Communication: Examples of communication skills most frequently reported as critical to job performance are the ability to collaborate effectively with others, the ability to communicate within multidisciplinary and multi-functional teams, and the ability to develop strong relationships with both internal and external customers. The adoption of sustainable practices across the organization cannot happen without the help of facilitators who can relate to all organizational functions and levels and carry out a shared vision.

Problem Solving: The emerging green economy is, in part, driven by the need to find innovative solutions to complex problems. Effective problem solving often requires creative thinking combined with technical knowledge and an understanding of the long-term financial and environmental impact of today's decisions. Examples of green activities requiring high degrees of problem solving are lean process improvements, remediation work, and all R&D activities.

Persuasion: Being able to influence change and handle conflict effectively are desirable skills listed as requirements in a small minority of green jobs. Yet this skill is indicative of the type of leadership needed to bring about change within an organization or among a group of stakeholders. Employers also listed coordination and negotiating skills when seeking ideal candidates.

Knowledge Requirements in Green Vacancies

The research revealed an important difference between skills and knowledge needed in green jobs: while skills are not inherently green, some types of knowledge are inherently green and differentiate green and non-green jobs within the same occupation. An example would be chemist versus a green chemist.

The survey asked about the importance of the following knowledge areas:

- Legal
- Science
- Mechanical
- Sales or Marketing
- Construction

Detailed results are shown in Figure 31.

FIGURE 31

Frequencies of Knowledge Requirements in Green Job Vacancies

Fall 2009 – Spring 2011

	Percent Requiring the Knowledge	Examples of How the Knowledge is Applied in Practice
Mechanical (Knowledge/Skills)[21]	44%	Operate a boiler at maximum efficiency, test hybrid vehicles, install pollution monitoring equipment in a manufacturing plant, troubleshoot laboratory testing equipment
Science	29%	Knowledge of chemistry or environmental engineering to interpret environmental data, thermodynamics to calculate how much energy a building is using
Legal	27 %	Knowledge of state and local policies related to land use and water resources, such as the Wetland Conservation Act
Sales or Marketing	19%	Knowledge of market analysis and segmentation techniques, product development, product commercialization, technical and consultative sales
Construction	19%	Knowledge of current construction materials and methods, understanding of construction processes and schedules

[21] Since employers did not distinguish between mechanical skills and mechanical knowledge, the results have been analyzed as one unique category.

About 44 percent of all estimated green vacancies required mechanical knowledge and/or skills. This might be expected given the high concentration of jobs in energy efficiency activities such as designing radiant floor heating systems and repairing energy-efficient HVAC systems. The next most common knowledge area (29 percent) was science knowledge, especially important for environmental conservation jobs. Legal knowledge, important in 27 percent of green vacancies, encompasses knowledge of environmental policies, regulations, and permitting processes.

Knowledge of sales was also cited as relevant, though less often than other disciplines because it applies to fewer occupations. Sales knowledge in green jobs is often based on technical knowledge of the product and the development of long-term relationships with the customer to identify new market opportunities and customized solutions. Lastly, construction knowledge was most often required for work in energy efficiency, including roofing, building inspection, plumbing, and installation of geothermal heat systems.

Within these broader disciplines there are plenty of opportunities for green specialization. Knowledge of the following topics can create a competitive advantage when applying for a green job:

Energy Efficiency: Understanding the principles and methods of energy conservation. This may include knowledge of energy auditing, energy efficient materials and processes, and installation of energy efficient systems.

Waste Management: Understanding different types of waste (mixed metals, various plastics, hazardous materials, municipal waste, etc.). Understanding how to reduce and manage different types of waste in residential, commercial, industrial, or municipal settings.

Pollution Monitoring and Control: Understanding tools and techniques used to monitor and control pollution. Having the ability to apply scientific or engineering knowledge to interpret chemical, biological, and physical measurements in order to design solutions for the prevention, mitigation, or remediation of environmental pollution.

Environmental Policies: Understanding local, state, and federal environmental policies, regulations, and permitting processes for individual firms or specific industries.

Natural Resource Conservation and Management: Understanding management principles for implementing or sustaining conservation practices or processes. This often requires scientific or technical knowledge, such as understanding local agriculture, fisheries, wildlife, or land use. Knowledge of community planning techniques is also valuable. It enables the evaluation of best practices to adapt them successfully to different ecological, social, and economic systems.

Chemistry, Material Science, and Chemical Engineering: Understanding the use of renewable sources that minimize pollution and waste while maintaining high levels of performance. Besides renewable fuels, new materials are being developed to prevent pollution and contamination at the molecular level. "Green chemistry" knowledge areas include design of chemical feedstocks, products, and processes for non-toxicity, material recyclability, reusability, biodegradability, and low footprint/low impact over the entire product life cycle. This understanding can open new horizons for utilization of biological resources in an environmentally efficient manner.

Lean Production and Operation Systems: Understanding of lean principles, processes, and tools to unlock hidden waste and promote long-term sustainability. This would include, for example, conserving natural resources while minimizing waste throughout all stages of an operational process (manufacturing, engineering, logistics, etc.).

Commercialization of Green Products: Understanding green industry trends and customer needs to identify opportunities for introducing, promoting, and distributing new green products and services. The purpose of many new product development positions is to lessen the price point to make innovative green products more affordable.

Computer Modeling Programs and Tools: Understanding modeling software applications such as hydrologic/hydraulic models, geological models, energy models, and 3-D graphical modeling applications such as Building Information Modeling (BIM).

Spatial Analysis and Management of Geospatial Data: Understanding the use of Geographic Information Systems (GIS), Global Positioning Systems (GPS), and other mapping and data management applications for environmental design and natural resource management.

The following verbatim answers illustrate major skill demand trends and/or skill gaps employers are anticipating in the near future.

Survey Question: Do you see any trends in new skills and knowledge that you believe will become essential to this position as we see a greening of the economy?

"Ongoing learning will become essential to this position as the field evolves with new technologies. For example, technologies for less invasive construction or harvesting of materials would definitely be advantageous for our clients."
—Hydrologist/Geologist

"Helping us in making sure we are scaling up robust green and sustainable products will always be a benefit for this position. Right now our focus is on sustainability, so a lot of the products this position is helping to scale up are going to be used in facilities where the obligation is the reduction of a carbon footprint and an increase in sustainability." —Chemical Engineer

"It will become more and more critical to have interdisciplinary background to bridge knowledge across fields and to work with engineers, social scientists, attorneys, etc. It takes different types of people to work on these types of projects." —Environmental Scientist

"One of the emerging areas of importance that cuts across conventional disciplines has to do with the understanding of the effective use of biological resources. We've been centered around using petroleum for fuel, agriculture for food, and forests for paper and building material. We need people who are educated in looking at these resources for other uses and studying that."
—Environmental Engineer

"Our environmental and safety manager is working with our stationary engineers to determine how to be more energy efficient, and I assume we'll put in newer technology over time that this person would need to understand and operate."
—Stationary Engineer/Boiler Operator

"There are a lot more problem materials than there used to be, for example e-waste, and that's changing every day. New things are popping up they have to deal with."
—Inspector and Tester

"Understanding of building automation systems will become more important. Most buildings have some form of system now, and everybody's increasing their capabilities to save energy."
—HVAC Technician

"Being aware of new technologies for water treatment. It is a rapidly changing technological environment." —Civil Engineer

"Today we prefer, and in the future it may be more important, to have knowledge of lean/six sigma quality improvement systems. We're always looking for efficiencies. Today it's a bonus to have that. In the future I think it may become a requirement."
—First-Line Supervisors/Managers of Production and Operating Workers

"The renewable energy area is something that we as a firm could potentially get into, and recycling pollutants is also a possibility. For example, if we shut down a gas station now we just burn off the excess fuel there, but I could see this position working on finding ways to reuse that fuel in the future."
—Engineering Manager

"Conflict resolution, problem solving, and decision making skills are becoming more important as we're working more and more with people with conflicting interests in the forest." —Supervisors/Managers of Farming, Fishing, and Forestry Workers

"The position is becoming more important for cities and communities. We get constant phone calls from communities that want to 'green up' public spaces, that's usually how they phrase it, or to make sustainable communities. It is becoming very critical, and it will become one of the most important design issues in the 21st century. Our architectural students do well with green buildings, but when you give them open ground in a large urban context, a sustainable city or neighborhood, they don't really seem to understand. Perhaps it is our fault for not offering enough courses in sustainability. Landscape architects are much closer to understanding this issue."
—Landscape Architect

"The ability to understand and execute sustainable design is very important, whether it be LEED or something else."
—Architect

"Our company is moving towards reusing waste streams, so more of an ecology background could become valuable in the future."
—Environmental Science and Protection Technician

"Everything they design these days has to take in to account the natural habitat and wildlife. For example, for using rainwater efficiently."
—Land Surveyor

Hiring Difficulties

Are employers always able to fill green job vacancies? Is there a mismatch between what recruiters are looking for and what they are finding in terms of skills and other workforce qualifications? Because of the cooling effect of the latest recession on the job market, most firms could tap into a large pool of qualified candidates to fill open positions. However, survey questions designed to measure hiring difficulties did identify short-term[22] labor market shortages in the green economy despite the abundance of labor supply during the study period.

As illustrated in Figure 32, more than a quarter of vacancies were reported by employers as "hard to fill" due to applicants' qualification gaps. Interestingly, nine out of ten cases of hiring difficulty were caused, entirely or in part, by "lack of experience." The second most frequently reported hiring difficulty was lack of skills, knowledge, or abilities. These two causes were often interrelated in employers' minds. As a respondent phrased it, "The candidate's pool lacked depth or breadth of knowledge, which often comes from experience."

Shortage of applicants with the required formal degrees, certifications, or licenses accounted for 28 percent of cases.

Hiring difficulties in green vacancies, like wage characteristics, were strongly related to the occupation. Employers reported the most

FIGURE 32

Type of Hiring Difficulty Related to the Candidates' Pool

Fall 2009 –Spring 2011

Reason Cited by Employer	Percent of all "Hard to Fill" Cases	Most Commonly Cited Gaps, Ranked by Frequency
None or not enough applicants with the right level or type of work experience	89%	• hands-on experience using environmental modeling software tools • engineering experience, especially substation engineering and wastewater treatment facility design • project management experience • HVAC and refrigeration experience • combination of science and engineering experience • energy management, energy auditing, energy modeling • renewable energy industry experience • laboratory experience • sales experience in a specific industry • commercial vehicles' driving experience
None or not enough applicants with the right skills, knowledge, or abilities	25%	• mechanical skills, knowledge, and aptitude • other specialized technical skills and knowledge (for example, technical understanding of HVAC systems) • material science knowledge • knowledge of environmental regulations
None or not enough applicants with the right level or type of formal education credentials	22%	• HVAC training • BS in chemical engineering
None or not enough applicants with the appropriate certifications or licenses	6%	• Wastewater Operator certification
Total estimated vacancies reported as "hard to fill"	28%	

[22] Since hiring difficulties were measured between one and four months from the vacancy's posting date, they represent short-term labor market mismatches.

hiring difficulties in the following occupational groups: Engineering (40 percent hard to fill), Business and Financial Operations (40 percent), Life and Physical Scientists (33 percent), and Maintenance and Repair (33 percent). As noted in previous chapters, these are also the occupational groups where a "wage premium" was observed in comparison to the total population of vacancies. In terms of industry, Engineering Services (NAICS 541330) reported the most "hard to fill" vacancies.

These findings reveal that, for green vacancies, the qualification gaps most commonly reported by employers are in specialized fields that go beyond the traditional preparation needed to work in an occupation. Therefore, even candidates who are qualified to work in a certain occupation might not be perceived by employers as competent enough to work in green sub-specialties within the same occupation. For example, electrical and mechanical engineers might need to demonstrate higher levels of technical skills (for example, how electrical and mechanical systems interact in a large facility), specialized knowledge of new technologies or tools (for example, environmental controls or energy modeling software), and/or industry-specific experience (such as energy management) to work competently on a green project such as building commissioning.

These results also offer a plausible explanation for the "wage premium" observed in some green jobs: starting wage offers are pushed higher when not enough candidates hold the desired qualifications. Industry-specific experience can be hard to find because these industries are so new, like renewable energy, or because the technologies and tools are too new to be taught at school or learned on the job.

Research results clearly demonstrate that the greening of the economy is having an impact on the skill and knowledge requirements of today's workforce. The most significant changes are apparently driven by the introduction of new green technologies or by the expansion of existing technologies to green applications. The next chapter is dedicated to exploring these dynamics.

"Research results clearly demonstrate that the greening of the economy is having an impact on the skill and knowledge requirements of today's workforce."

9 GREEN AND GREEN-ENABLING TECHNOLOGIES

Does Minnesota have the companies and the technology to develop commercially viable green products and services? How is the diffusion of green and green-enabling technologies affecting the workforce? Employers were asked to identify specific technologies or technical advancements that have the potential to affect future job tasks and skill sets for their open positions, and ultimately unlock the value of emerging green markets.

According to research findings, several Minnesota-based firms already possess technological strengths in areas with broad potential applicability to green purposes. Some technologies are green or "clean," defined as leading to operational performance, productivity, or efficiency improvements while reducing costs, inputs, energy consumption, waste, or pollution. Others are called "green-enabling" because, though not created with the intent of benefiting the environment, when embedded in green products they can dramatically increase environmental performance.[23] Here are some examples.

[23] Wireless technologies, for example, though not developed with the purpose of increasing energy efficiency, are essential to the functioning of energy-efficient products such as sensors and switches for lights and appliances, and even to the implementation of the smart grid.

Biochemistry

The most transformative green technologies are emerging from biochemistry research, which has spurred the development of two families of green products: biopolymers and green chemistry products. While Minnesota currently has limited manufacturing activity in these areas, increasing international demand might favor future production.

Biopolymers are entirely new chemicals derived from biomass sources (corn or other agricultural and wood residues) that could revolutionize chemistry and open up new markets for plastic components to be used in all kinds of products, including automobile parts, electronics, kitchen utensils, containers, and packaging. The greatest technological challenges are to develop competitively priced bio-based plastics that perform as well as petroleum-based ones, and to expand from single-use (the classic compostable plastic bag, for example) to durable use applications. Minnesota has a strong traditional plastics industry which could provide a platform for integrating biopolymers.

In the green chemistry arena, comprising non-toxic personal care and cleaning products, the market appeal is a reduction in exposure to environmental and health hazards. Complex eco-toxicological and regulatory reviews are often needed for the commercialization of these green products.

Advanced Materials and Nanotechnology

Other exciting developments with broad green product applications are taking place in the field of materials science. A few examples are coatings, nano-materials for solar photovoltaic panels, thin films and adhesives for semiconductor applications. Strengthening Minnesota's presence in these technologies would establish the long-term capability to develop materials that reduce resource intensity and carbon footprint,[24] for which future market demand is anticipated. As with biopolymers, materials science technologies generally take decades to move from basic research to full commercialization. Because of the considerable upfront costs of investment, this area of technology might benefit from strategies to accelerate technology validation, market development, and commercial readiness.

Renewable Energy

Although some renewable energy technologies require substantial upfront investments that can discourage market adoption, the increased popularity of on-site, decentralized generation (referred to as Distributed Generation) has the potential to make them more appealing and affordable in the near future. While Distributed Generation systems have traditionally been fueled by natural gas and diesel, the push towards decentralization is likely to increase the application of renewable sources. In fact, as power generation moves closer to the point of consumption (residential, commercial and industrial users) the public will be less likely to tolerate dirty sources, like diesel generators, that can impact local air quality. Clean technologies that can see future growth if chosen as options for Distributed Generation systems are solar thermal electric, photovoltaics, landfill gas, wind, biomass, hydroelectric, geothermal (both electric and thermal), municipal solid waste, District Energy, and combined heat and power (cogeneration) systems. The latter, in particular, can achieve significant environmental performance through the capture of waste heat and improved distribution efficiency. Although connecting these systems to the distribution network and with existing utilities can be technically and contractually complex, Distributed Generation has the potential to become an alternative to larger utility scale operations.

Waste Treatment and Recovery

Waste conversion technologies such as composting, fermentation, methane digestion, gasification, and pyrolysis of biomass are moving beyond traditional incineration. The product outputs from these technologies include electric and thermal energy, biofuels, syngas, and other co-products. Barriers to market entry include cost and the ability to secure feedstocks.

Significant new applications for waste recovery systems show potential for growth. A number of Minnesota facilities are retrofitting waste water treatment plants with methane digesters. Projects are also emerging that convert other industrial waste streams, such as those from food processing

[24] Carbon Footprint measures how much burning of fossil fuels (with corresponding emission of carbon dioxide) is needed for a specific human activity including manufacturing a product, driving to work, or cleaning up a contaminated site. Carbon dioxide will accumulate in the atmosphere, contributing to global climate change, unless it can be captured and stored by plants.

facilities. Technology companies manufacturing components of these systems, such as Cummins Power Generation with combined heat and power system, are already at commercial scale. Others, such as SynGas Technology, LLC, with advanced gasification technology are moving beyond the lab to commercial scale.

Energy Generation, Storage, and Distribution

These technologies include advanced batteries, energy conversion, power management, and data storage solutions. Minnesota has an established battery manufacturing industry that could become more involved in energy-focused applications in the future if demand conditions are favorable. Although it will take decades for the smart grid to be implemented, these technological advancements are the building blocks of a well-integrated infrastructure to harvest and distribute wind and solar energy and minimize power losses in the delivery of electricity.

Wireless and Control Technologies

These "green-enabling technologies," though not developed with the purpose of benefiting the environment, are embedded in a wide variety of green products ranging from control instruments for monitoring greenhouse gas emissions to smart meters allowing utilities and consumers to track energy consumption in real time and make more educated decisions about energy use.

Transportation Technologies

These are already established in Minnesota and include exhaust filters manufacturing, alternative fuel vehicles manufacturing, and emissions-reduction engine technologies. Some are end-of-pipe solutions, such as retrofitting existing engines with pollution control equipment, while others are cleaner in the sense of reducing pollution at the source, such as designing engines that eliminate pollutants before they are formed.

Potential Labor Market Impacts of Green and Green-enabling Technologies

Technological innovation is critical to growth in the green economy for two main reasons. First, just as technological readiness can accelerate the adoption of green products, technological barriers can hinder the creation of markets for much needed green products such as solar photovoltaic applications. Second, the definition of "green" itself is subject to change as technologies evolve over time. For example, retro-fitting diesel engines with diesel oxidation catalysts to reduce emissions will stop being viewed as a green activity when a new generation of hybrid and electric-powered vehicles fill the roads. As the definition of green activity changes, the definition of green jobs will also change.

Research evidence revealed that private sector companies in Minnesota are gradually incorporating green and green-enabling technologies into their product portfolios.[25] The majority of respondents who answered affirmatively to the question "Do you see any trends in new skills and knowledge that you believe will become essential to this position as we see a greening of the economy?" pointed to the need to upgrade their employees' technical skills to work on evolving technologies.[26] These are signs that technological change may have a substantial impact on Minnesota's workforce in the coming years.

The green economy relies more on innovation and technology compared to non-green sectors because environmental problems often require highly technical, one-of-a-kind solutions. For example, cleaning up a contaminated site while at the same time minimizing the negative effects of operating heavy equipment, requires the adaptation of technologies to unique site conditions such as soil, groundwater, and native habitats. Since one size does not fit all, technologies are continuously adapted, creatively customized, or re-invented.

In terms of occupations, the types of jobs more likely to need an upgrade in skills and knowledge to keep up with evolving green and green-enabling technologies are scientists, engineers, maintenance and repair technicians, technical sales representatives, and business operations specialists. For example, a training development specialist might be responsible for training the sales force in the energy-efficiency technologies embedded in a HVAC system, while an engineer might evaluate the feasibility of new waste conversion technologies to help a local municipality prevent waste from going into landfills. On-the-job

[25] Additional anecdotal evidence from interviews revealed that some manufacturing companies with R&D divisions in Minnesota plan to incorporate green technologies more intensively in their future product lines.

[26] A fairly typical response to this survey question was "Ongoing learning will become essential to this position as the field evolves with new technologies."

training in new technologies is the tool preferred by employers to train their workforce in the specific green component of the job.

In terms of industries, the fact that small, private sector firms reported green job openings from 2009 to 2011 in industries like scientific R&D and manufacturing, sectors that were particularly hard hit by the latest recession, stands as remarkable evidence of the source of economic resilience and renewal green activities can represent for our state.

The Path from Technical Advancements to Green Products/Services

In what ways are Minnesota companies forwarding the technological innovations that can spur growth in the green economy? SAGE Electrochromics, a glass company in Faribault, and Segetis and Reluceo,[27] two biopolymers firms in Golden Valley are examples of companies dedicated to developing new green technologies. Innovative green companies face the same set of hurdles that hold back any new technology. First, there are difficulties of capitalization, especially for start-ups caught in the double crunch of financing a manufacturing facility and moving to large-scale commercialization. Second, investing in green product performance improvements can be risky and costly especially when newer technologies haven't demonstrated themselves in the marketplace and do not yet have the economic support that more conventional technologies have. Just as many innovations are viewed as "fads" when first introduced, green technologies are sometimes viewed with suspicion compared to established technologies. Third, proving the effectiveness of green product features is difficult in the absence of broadly recognized, objective, and reliable metrics that customers can understand and use to compare products. Although there is plenty of evidence that consumers want improved environmental features in products, the existence of false, superficial, or misleading green product claims, often referred to as greenwashing, has led to negative repercussions for the whole category, creating confusion and skepticism in consumers. Sometimes it can also happen that a product attribute is not as green as promoted. This dynamic is not new to green. One just has to look at the use of the word "natural" associated with products to find similar market confusion.

For all of these reasons, several firms in Minnesota are investing time and resources to educate and inform customers through a blend of consultative sales, creative communications, and the use of reliable standards and product labels/certifications. Firms that view the term green as too elusive or too broad prefer to promote single dimensions of environmental performance, such as "durable," "energy and resource-efficient," "healthy," "organic," or "renewable." Other firms try to expand green to the broader notion of sustainability.

Even firms that do not consider themselves green and do not directly invest in clean technologies can identify a potential green feature of an existing product and use it as a selling point. While these approaches may not lead to the development of new green products, they can contribute to continuously expanding the range of green applications for existing products or technologies. For example, a manufacturer of precision instruments for the measurement of air particles can apply its technological knowhow to air pollution testing purposes. The improved sensitivity of instruments, in turn, can enable better decisions on how to prevent and mitigate air pollution. Likewise, manufacturers of plastic compounds can extend the use of composites to fuel cell applications, taking advantage of composites' superiority over metals in versatility of design and/or heat resistance.

Figure 33 lists examples of green product features with representative metrics, standards, labels, and certification programs that can give firms a competitive advantage in the market. The examples included in this chart are not meant to endorse any performance measurement system or standard. The intent is purely to illustrate a few emerging trends that could drive future market demand, especially as U.S. and international law starts to require the use of metrics to support any "green," "environmentally preferable," or "sustainable" product claims. Furthermore, it is important to point out that eco-certifications and labels can be a double-edged sword if the standards are set too low or fail to adapt to evolving technologies. They can stifle innovation rather than promote it by failing to acknowledge cases where products exceed standards.

[27] Although these two companies do not yet have manufacturing capability, they are actively engaged in product development and commercialization with the aim of scaling up production.

FIGURE 33

Examples of environmental performance features of green products/services and emerging metrics and standards

Environmental Performance Features	Definition	Examples of Performance Metrics, Standards, or Certifications
Durable	Products designed for future life cycles, i.e., designed for recovery. For example using components and raw materials that can be disassembled, recycled, or composted	• Cradle to Cradle (C2C) certification[28]
Energy and resource-efficient	Products and processes/practices that use less energy (electricity and/or natural gas) or resources (water, wood, and other raw materials) to perform the same function at the same level of quality.	• Energy-Star • Environmental Management System (EMS) according to ISO 14001[29]
Healthy	Products that are safe for people and the environment	• Green Seal[30] • Cradle to Cradle (C2C) certification • Indoor Air Quality standards
Low Carbon Footprint	A product or a service that emits a relatively low total amount of CO2 and other greenhouse gases over its full life cycle.	• Accounting systems based on Carbon Footprint measurements
Low or reduced-emission	Engines that deliver the same performance with lower carbon dioxide and other toxic emissions; processes and/or technologies that reduce emissions in power plants.	• EPA Clean Diesel Truck/Bus national control program
Organic	Produced or grown without added artificial substances and without the use of toxic substances in the process (pesticides, herbicides, etc.)	• United States Department of Agriculture (USDA) Organic label
Renewable	Made from renewable materials or energy	• For materials: USDA BioPreferred program[31] • For energy: Certified Green-e Power[32]
Sustainable	Products and services that minimize environmental, social and economic impacts over their full life cycle. Might imply the use of durable and responsibly harvested materials	• Smart Sustainable Products Standards[33] • U. S. Green Building Council Leadership in Energy and Environmental Design (LEED) Rating System • Forest Stewardship Council (FSC) certification

In summary, a steady flow of innovation is necessary to enable the transition to the green economy. The contribution of innovative green firms goes well beyond moving emerging technologies toward commercialization. Their high performance products and services can help educate consumers, making it easier for them to distinguish authentically green solutions from greenwash. This can literally transform the marketplace and accelerate adoption of other kinds of green products. Furthermore, the diffusion of advanced knowledge and technologies will position Minnesota as an international player. Some of the technologies being developed in Minnesota, especially green chemistry products, are manufacturing-intensive, and have an existing global demand. If companies wait too long for consumer preferences to change before moving forward with green innovations, Minnesota may miss an opportunity to compete in high value-added industry sectors.

[28] The Cradle to Cradle Certified program is a multi-attribute eco-label that assesses a product's safety to humans and the environment and design for future life cycles.

[29] The International Organization for Standardization (ISO), a voluntary certification system for manufacturers, defines environmental management systems as "that part of the overall practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy." EMS focuses on environmental management practices rather than the activities themselves. It provides the structure by which certain activities can be carried out.

[30] Green Seal sets life cycle-based environmental standards and awards a "Green Seal of Approval" to products that cause less harm to the environment than other similar products.

[31] Under the USDA BioPreferred Program, Federal agencies and their contractors are required to buy products with the highest biobased content, defined as products composed in whole, or in significant part, of biological products, renewable agricultural materials, or forestry materials.

[32] The Green-e Renewable Electricity Certification Program is meant to encourage consumer confidence in buying "green" electricity, defined as electricity that is generated from at least 50 percent from renewable sources such as the sun, water, wind, burning of wastes (biomass), or geothermal heat from the earth.

[33] These are very comprehensive standards requiring the use of Life Cycle Analysis for Certification. A product life-cycle analysis calculates the overall carbon footprint and other environmental impact categories of the product from its manufacturing, transportation, and use to final disposal.

10 THE FUTURE OF GREEN

Is green truly an emerging sector? Is it generating jobs? Empirical evidence accumulated over two years of research and presented in the previous chapters demonstrates how the greening of the economy is affecting the labor market, with detailed measurements by region, industry, and occupation. Although growth in the number of job vacancies over time does not represent net job growth, vacancies are particularly well suited to the detection of emerging economic sectors.

FIGURE 34

Growth in Green Vacancies Compared to Total Vacancies

	Growth Fall 2009-Fall 2010	Growth Spring 2010-Spring 2011	Average Growth
Total Vacancies	31 percent	32 percent	+ 31 percent
Green Vacancies	15 percent	46 percent	+ 30 percent

Overall Growth in Green Job Vacancies: Fall 2009-Spring 2011

After bottoming out in fall 2009, job vacancies started to pick up in spring 2010 and more than doubled in size returning to pre-recession levels by spring 2011. Green vacancies grew an average of 30 percent, compared to 31 percent for all vacancies.

Survey findings thus indicate that, when measured by green job openings conservatively defined, the green economy represents a small yet stable share of overall employment with the potential for rapid growth as the global economy recovers. As shown in Figure 34, green jobs tend to grow faster in spring than in fall because of seasonal outdoor work such as water sampling in lakes, park-related maintenance, reforestation, and clean-up activities.

Are Green Vacancies New or Replacement Jobs?

Another way of measuring growth is to identify positions that open up as a consequence of increases in green business activities. The majority of respondents, 54 percent, stated that theirs was a newly created position, not a replacement opening to fill a position recently left vacant as a result of retirements or turnover. Since newly created positions represent "growth openings" created by economic expansion, this finding is an indicator of the emerging nature of the green economy. To put it in perspective, according to employment projections only 28 percent of future projected openings in Minnesota from 2009 to 2019 will be created as an outcome of growth while the remaining 72 percent will be replacement openings.

New green positions were typically created when incumbents could not handle the increase in green-related responsibilities, either because of too few staff or because existing staff did not have the new competencies required. An example of the first situation is a manufacturing plant hiring more environmental engineers to oversee an increasingly complex environmental permitting process. An example of the second situation is a firm hiring for a position that is completely new to the company, like a sustainability coordinator. Employers may not even have job descriptions for these new green specialties yet.

A direct quote from a respondent illustrates what new positions can represent for employers: "This is a new position for our company. In the past we've partnered with other firms for this service, but then decided we want to have someone in-house with this expertise."

Growth Potential of Green Sectors

Owing to seasonal effects, the data do not support making comparisons of hiring demand growth by green activity area. However, the information collected through interviews with recruiters and industry experts revealed several factors that can drive employment growth within each green sector.

Energy and Resource Efficiency

Of all green activities, energy efficiency is the most promising in terms of job creation. Several factors contributed to strong growth. First of all, despite the long pay-back periods, investments in energy efficiency are a relatively low-hanging fruit. By focusing on the two largest consumers of energy in buildings, air conditioning and lighting, existing buildings can be made as energy-efficient as brand new ones. Second, although the sharp decline in new construction has hampered the growth of green architectural services since the crash of the housing market in 2007, the pool of existing houses and facilities needing insulation in Minnesota is still large. Retrofitting work is ongoing, labor intensive, and often locally sourced. The third favorable condition is the regulatory environment: Minnesota's building energy codes are relatively more stringent than those in other states, motivating homeowners to spend money on energy-conserving building practices. The fourth favorable condition is customer demand. Homeowners are becoming informed and savvy enough to push for certifications such as LEED and EnergyStar,[34] which in turn can spur innovation in green building materials and encourage

[34] The equivalent of LEED in existing buildings.

the technical expertise needed to accomplish the work locally.

Recycling and Pollution Prevention

The shift in emphasis from end-of-pipe treatment methods to prevention of environmental problems is likely to increase demand for workers in this sector. The incentives to recycle are strong not only as an alternative to waste disposal but also to increase availability of manufacturing feedstock during times of rising raw material costs. Economic activity around recycling is strong in Minnesota, involving businesses as varied as curbside collection services, electronics and computer components recycling centers, paper mills and other manufacturers using scrap or post-consumer materials to produce recycled-content goods.

The increasingly popularity of LEAN production methods is another potential source of job growth in this sector. While a minority of lean initiatives is currently focused on green purposes such as waste minimization, green is being embraced as an "extra bonus" to improve a company's environmental standing. Even service-sector firms see the benefit of hiring workers specialized in applying waste-minimization approaches to logistics and supply chain operations.

Lastly, the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances is another emerging field of activity, commonly referred to as green chemistry, with growth potential in Minnesota.

Natural Resource Conservation

Growth in this sector will be driven primarily by deepened public awareness of the connections between human and ecosystem health. From purchasing organic produce to taking a stand for more bicycle paths and protected park areas, healthy living concerns are becoming more mainstream.[35] As communities strive for "greening up" public spaces to enhance property values and increase quality of life for residents, green design will increasingly be incorporated into architectural, urban landscape, and redevelopment projects. Lastly, as more people see a stake in decisions around the use of local natural resources, jobs will be supported in conservation planning, land and forestry management, spatial inventory and monitoring of natural resources.

Environmental Compliance

Environmental compliance has been a foundation and primary driver for pollution control, clean-up, and environmental protection. Green jobs have been created as a result of the implementation of regulations such as the Clean Air Act[36] and the National Environmental Policy Act (NEPA), which push firms, especially manufacturers and utilities, to dedicate more staff resources to environmental health and safety compliance, pollution monitoring, and environmental permitting.

As national and global environmental challenges become more complex, new regulations beyond those existing may be introduced, prompting companies that compete internationally to integrate localized regulatory regimes. At the same time, market-based approaches which reward higher performance and penalize pollution and waste will also grow, creating a need for centralized business functions dedicated to sustainability planning, Corporate Social Responsibility[37] reporting, and green supply chain operations. These new market trends will require firms to develop the necessary staff expertise and capacity to address them.

Renewable Energy

The regulatory and policy framework will continue to play an important role in the future development of this sector, for good and for bad. Minnesota has a stringent renewable energy standard requiring utilities to produce 25 percent of their sales from renewable fuels by 2025, with wind power being the overwhelming choice. A market around wind is starting to develop as confirmed

[35] Nationwide, organic foods are one of the fastest growing segments in agriculture.

[36] The Clean Air Act is the law that defines the Environmental Protection Agency's responsibilities for protecting and improving the nation's air quality and the stratospheric ozone layer. The last major change in the law, the Clean Air Act Amendments of 1990, was enacted by Congress in 1990. The law requires states to make constant formidable progress in reducing emissions, and requires the Federal government to reduce emissions from cars, trucks, and buses; from consumer products such as hair spray and window washing compounds; and from ships and barges during loading and unloading of petroleum products.

[37] Although the adoption of Corporate Social Responsibility (CSR) policies and reporting is still at its early stages, consumers and investors will expect more transparency in the way businesses account for the social and environmental impact of their operations.

by the fact that several employers in construction and engineering services have added wind to their portfolio. However, the intricacy of the permitting process for the installation of wind farms has not facilitated growth in this sector.

Every further delay in the development of the technological infrastructure to harvest and distribute renewable energy might prevent electricity generation from clean sources like wind and solar from becoming price-competitive compared with that generated from fossil fuel sources.

Pollution Control

Rather than net job growth, this sector is likely to experience an increase in workforce skills (and inevitably wages) as remediation work becomes more challenging and the cost of non-compliance rises, ranging from penalty fees to damage to a company's reputation. The desire to avoid adverse impacts of cleanup activities is forcing a more thorough evaluation of alternatives (including "no action") requiring not only an interdisciplinary approach but also the ability to identify complex cause and effect relationships. Given the difficulty of recruiting talent with such a deep and diverse set of competencies, on top of stricter licensing and certification requirements for work involving hazardous materials and/or government contracts, employers in this sector might experience some workforce shortages in the future.

Furthermore, the way current environmental regulations are being implemented, especially greenhouse gas emissions policies,[38] could create demand for experts to oversee pollution monitoring programs and install pollution monitoring equipment.

Clean-up and remediation work, in turn, can stimulate demand for specialized products and technologies for detecting and monitoring pollution in water, air and soil. Since some of these products are already manufactured locally, new employment opportunities in manufacturing could arise as the sector expands.

Water Treatment and Conservation

The fact that Minnesota appears to lag behind in this green activity area makes future growth likely. Some workforce shortages are expected in wastewater treatment operations and facility engineering design as both the workforce and the infrastructures are aging. Furthermore, any kind of land use activity nowadays must take into consideration water resources both above and below the surface. The implementation of best practices can employ, among others, engineers, project managers, and land surveying professionals.

A discussion of growth in the green economy cannot be complete without acknowledging the dynamic and diffuse nature of the sector. The greening of the world of work is unfolding gradually and quietly, without sudden growth spurs. Jobs that devote less than 50 percent of their time to green tasks, not included in this research, are also becoming pervasive and might transition to the green economy in the near future.

[38] In January 2011, Clean Air Act permitting requirements for Greenhouse Gasses kicked in for large facilities that are already obtaining Clean Air Act permits for other pollutants. Those facilities are required to include GHGs in their permit if they increase these emissions by at least 75,000 tons per year.

11 CONCLUSIONS

Just like every research project, the present study offers a static picture or short movie clip that is subject to change. This is even more true in the context of the green economy, where the concept being measured — "high environmental performance"— continues to evolve as technologies improve. When today's best environmental solutions are surpassed by cleaner ones, some of today's green jobs may not be quite so green.

In terms of Minnesota companies' attitudes toward the research topic, we encountered a variety of reactions: some respondents were quick to consider their organizations and related jobs as green, and others were more careful and conservative in their deliberations when answering questions about potential greenness. Some stated directly that, while they considered their positions to be legitimately green, they didn't want to appear to be greenwashing. A respondent's quote encapsulates these concerns:

"We have a truly green product, but we've not marketed it like that. We have had a sensitivity and awareness of not marketing our product specifically as green because we didn't want to be lumped in inappropriately with a bunch of other products — some of which are green and some of which have been subject to greenwashing. We're very proud of the social contributions our product makes, but we want the performance of the product to speak for itself."

If firms that fully embrace the concept of environmental responsibility are unwilling to identify with the term green because of its ambiguousness, it is unlikely that the label will help market products and services with authentically high environmental performance. This would be a lost opportunity for the environment as well as for the regional economy. Findings from studies like this one contribute to separating the myth from the truth, forcing clearer definitions of industries, occupations, and product benefits that resonate more with the public and the business community. Businesses are thirsty for meaningful and comparable definitions that fit their image or product or brand. "High environmental performance," "energy efficient," "renewable," "durable," and "organic" are terms often preferred over green because their authenticity can be measured.

Although public dialogue has recently been focused on green job definitions and the job creation potential of the green economy, it is important to recognize that green jobs are only the tip of the iceberg of the green economy. Equally important components are, among others, green technology advancements, evolving consumer demand for green products/services, and the pace of adoption of green practices and processes within individual firms. As outlined in this report, these components have great potential as drivers of growth for green jobs conservatively defined as predominantly engaged in environmentally beneficial activities. However, every firm can make a contribution to Minnesota's green economy regardless of how many, if any at all, green jobs it offers, for example by investing in green technologies or by minimizing energy utilization and waste. By reducing and preventing negative environmental impacts, businesses can reduce costs from inefficient use of resources. These savings can be reallocated to more productive economic activity than managing emissions and wastes.

Also, each one of us can contribute to the transition to a carbon-neutral economy as we allow environmental performance considerations to become part of everyday decisions on what we buy and what we do. With everybody's contribution Minnesota will be better able to compete in the marketplace with commercially viable green products and solutions, offering more choices to consumers while driving demand for high-skill and high-pay work.

It is clear that the research accomplishments of this project stretched beyond the stated goals. The methods and tools of inquiry experimented within this study can be adapted and replicated to the investigation of other emerging sectors of the economy. Improvements in data collection and analysis increase the capacity of labor market information products to respond to the rapidly evolving information needs of job-seekers, students, policy-makers, educational institutions, and businesses.

12 APPENDICES

Appendix I:

Grant Overview

Funding for this project was provided by an American Recovery and Reinvestment Act of 2009: State Labor Market Information Improvement Grant through the Department of Labor, Employment and Training Administration. The following provides background on the purpose of these grants.

Recovery Act: Competitive Grants for Green Job Training

On February 17, 2009, President Barack Obama signed into law the American Recovery and Reinvestment Act of 2009 (Recovery Act) through which Congress intended to preserve and create jobs, promote the nation's economic recovery, and assist those most impacted by the recession. The purpose of these grants, which fund both green job training and research projects, is to teach workers the skills required in these emerging energy efficiency and renewable energy sectors. These efforts will lead program participants to job placement while leveraging other Recovery Act investments intended to create jobs and promote economic growth.

State Labor Market Information Improvement Overview

The State Labor Market Information (LMI) Improvement grant program is supporting the research and analysis of labor market data to assess economic activity in energy efficiency and renewable energy industries and identify occupations within those industries. These grants invest in state and consortium models designed to collect, analyze, and disseminate labor market information and enhance the labor exchange infrastructure for careers within energy efficiency and renewable energy industries. State Workforce Agencies will use this workforce and labor market information and data as the foundation on which to build and implement effective workforce development strategies. Multiple State Workforce Agencies working together in a consortium will use this program to conduct research that may potentially have a regional, multi-State, or national impact.

These investments are designed to achieve the following results:

- The development of effective methods for estimating the impact on industry and occupational employment resulting from implementation of green technologies.
- The dissemination of research and data through

outreach strategies that inform job seekers, the public workforce system, education and training providers, and other organizations of the occupational skills and growing needs of the energy efficiency and renewable energy industries.

- The development of other related research that provides insight into the State regulatory environment, an understanding of current programs of study and related credentials, and an identification of capital investments in green industries.
- The posting of job openings to online job banks that will be highlighted for easy recognition as green jobs by job seekers, as well as the highlighting or development of other online tools and approaches that will encourage local residents to prepare for and apply for jobs being created in their local area.

Grantee Summaries

Thirty awards ranging from approximately $763,175 to $4 million each were made to State Workforce Agencies. Minnesota's grant overview is included below. Other states' overviews can be viewed at http://www.doleta.gov/pdf/LMI_Grant_Summaries_02052010.pdf

Grant Program:	State LMI Improvement Grants
Grantee Name:	Minnesota Department of Employment and Economic Development
Grantee City/State:	St. Paul, Minnesota
Grant Award Amount:	$1,155,488
Period of Performance:	December 2009 - May 2011 (grant was extended with no additional funding through September 2011)
Project Name:	Green Labor Market Information Project
Project Description:	Minnesota's State Labor Market Information Improvement Program proposes a four-part research project that will fill the green information gap and enhance labor exchange infrastructure and efforts. This project will leverage Minnesota's established Job Vacancy Survey (JVS), to conduct an in-depth follow-up Green Jobs Survey; mine Minnesota's state job bank for additional data and identify green job openings; collect comprehensive data on green educational programs; develop an enhanced state specific crosswalk between occupations and training courses; and develop industry competency models for key groups of new and emerging green occupations. The research will identify demand for green jobs, skill requirements, and labor force shortages. Furthermore, this information will be utilized in order to ensure that education curriculum is aligned with the greening of the economy.
Areas Served by Grant:	Minnesota
All Project partners:	Governor's Workforce Development Council; Department of Commerce; Office of Energy Security; Minnesota State College and University System; ISeek Solutions; Minnesota Career Development Association; and Twin Cities RISE.
Project Deliverables:	• Comprehensive estimates of green jobs in MN, by SOC, across all industries • Estimates of green employment by occupation, industry, and region • List of green occupations experiencing labor force shortages • Comprehensive list of skill and education requirements for each SOC-O*NET occupation • A green identifier for postings in the state job bank • Web-based content and tools • Complete database of "green" educational programs • An enhanced MN-specific CIP-SOC crosswalk • Industry competency models • Outreach and training effort • Print and downloadable PDF reports • Green-enhanced LMI tools • ISEEK green careers and portal outreach

Final deliverables for this project included:
- Technical Report
- Labor Market Information Green Jobs Website — www.positivelyminnesota.com/GreenJobs
- Minnesota Green Careers Web Portal — www.MNGreenCareers.org
- Green Outreach Material — http://www.iseek.org/industry/green/outreach-materials.html
- Final Green Jobs Event — held May 24th at the Wilder Center in St. Paul (www.wilder.org)
- Variety of other marketing opportunities and materials including:
  Table and presentations at Minnesota State Fair and the Minnesota Green Expo.

Appendix II: 2011 2nd Qtr Minnesota Job Vacancy Survey

DIRECTIONS

- Please direct this survey to the manager or human resources professional responsible for hiring and recruitment at this location of your business. Please answer Part A below, and, if you have vacancies, turn the form over to complete Part B. No data identifying individual firms, directly or indirectly, will be published or released. If you have any questions about the survey, please call our toll free number at 1.888.234.1114 (select option #3).
- Please respond before XXXXXXX.
- Surveys may be returned by mail or fax. Return your survey by fax at 651.282.5429.
- If you have no job vacancies, you may call 1.888.234.1114 (select option #3) and complete your survey over the telephone.
- If you have an Internet site that lists your current job vacancies, you may call 1.888.234.1114 (select option #3) to provide the Internet address and complete your survey over the telephone.
- Summary results will be available in February 2011, visit: www.positivelyminnesota.com/jvs.

1: Total number of employees:

_____

Please fill out the survey for the entity listed in the upper right hand corner of this form.

2: Who is responding to this survey?

_____
Your name

_____
Title

_____
Phone Number

3: In the next 6 months, does this location of your firm plan to change current employment levels?

If so, how? (Please circle one letter below.)

A. Hire more employees to increase current employment level.
B. Decrease current employment level.
C. Employment level will remain the same.
D. Uncertain

4: Do you have vacancies at this location?

❑ Yes . . Turn over survey and complete Part B*. →

❑ No . . Do not complete Part B. Mail survey in the postage-paid envelope provided, or fax survey to the number listed above.

* If your business has an Internet site that clearly lists this location's current job vacancies, you may provide us with the Internet address in the comments section (at right) and return your survey without completing Part B.

Comments:

Appendix II: Part B- CURRENT Job Vacancies At This Location

	A	B	C	D	E	F	G	H	I
	Job Titles for Vacancies • Include positions you are actively recruiting for • Include full- and part-time, temporary and permanent workers • Exclude positions reserved for consultants, outside contractors and others not considered employees **Full-time = 35+ hours per week** **Part-time = 1–34 hours per week**	**Number of current job vacancies**	**Is this position seasonal/temporary?** Yes No	**Is this position engaged in any of the following? (Choose all that apply)** Environmental education, regulation, compliance or research Sustainable agriculture or natural resource conservation Environmental cleanup Energy efficiency Renewable energy/alternative fuels Not engaged in any of these	**What education level is usually required? (Choose one)** No education requirement High school or GED Vocational training Associate's degree Bachelor's degree Advanced degree	**Does this vacancy require a license or certification?** Yes No	**What experience is usually required? Choose one** No experience required Some work experience Experience related to position	**What is the expected hourly, monthly, or annual compensation?**	**What benefits are offered? Choose all that apply** Health insurance Paid time off (other than holidays) Retirement savings plan or pension No benefits offered
Full-time	Example — Junior Accountant							$45,000/yr	
	Example — Wind Turbine Technician							$3,000/mo	
Part-time	Example — Mail clerk							$7.15/hr	

Appendix III: Green Telephone Script (10-18-10)

Survey ID: _____ Job ID / Position(s): _____

Name/Title: _____ Company: _____

Phone: _____ NAICS: _____

Call Notes:

SECTION A. INTRODUCTION

Hi ___, I'm calling from the Minnesota Department of Employment and Economic Development. In our recent Job Vacancy Survey, your organization listed some job vacancies for positions that appear to contribute to environmental benefit or sustainability. I was calling in hopes of gathering some follow-up information about those positions so that—at the state level—we can better understand the greening of Minnesota's economy and the related needs of organizations. Would you be willing to answer some questions about those positions? (Let them commit.) Great, thanks. I have a series of questions that takes about 12 minutes to complete for each position—could we start with the position of _____.

And would it be okay with you if I record our conversation to ensure my notes are accurate information upon completion? The tape will be erased once I've finalized your answers.

SECTION B. IDENTIFYING GREEN JOBS

#1: Could you tell me about the typical tasks & job duties for the position of XXXXX?

#2: I'm now going to read 5 categories and—for each one—please let me know whether the position does any direct work in the given area—and yes/no answers are fine, but you're welcome to provide additional comments, too.

1. **Renewable Energy or Alternative Fuels Y / N**
2. **Energy Efficiency Y / N**
3. **Pollution Reduction/Prevention or Remediation Y / N**
4. **Sustainable Agriculture or Natural Resource Conservation** when relevant: This includes things that directly benefit the soil, water, air, plants, or animals and result in healthy ecosystems." Y / N
5. **Environmental Regulation, Compliance, Research or Advocacy Y / N**
6. **None of the above**

#3: Of the categories that apply [*re-read "yes" categories to person*] is there a category in which the position spends at least 50% of their time? If so, which one? (*If not, which activity occupies the majority of the employee's time?*)

#4: Would you say that…

1. **An essential role of this position is to create a product or provide a service that results in environmental benefits. (If yes, probe for details and put in text box.)**

2. **Any other ways in which this position results in environmental benefits that we've not yet discussed?**

IF 3.1 & 3.2 are both NO:
So, it's accurate to say that this position has nothing to do with providing products or services that improve the environment?

IF ALL NO & GREEN TITLE:
#5: Some research suggests that this position in your industry results in environmental benefits, could you help us understand why you feel differently?

***** TRUNCATE HERE IF NOT GREEN *****

SECTION C. POSITION REQUIREMENTS

#6: And which level of education is usually required for this position?
(Do not read options, but confirm coding.)

a) **No educational requirement**
b) **High school/GED**
c) **Vocational Training**
d) **Associate Degree**
e) **Bachelor's Degree**
f) **Advanced Degree**

#7: If vocational, associate's, BS/BA or advanced: **Which specific field(s) of study are you looking for?**

#8: And which of the following categories best captures the typical experience needed to qualify for this position?

a) **No experience required**
b) **General work experience**
c) **Experience in a related field**
d) **Experience in this occupation**

Appendix III *(continued)*: Green Telephone Script (10-18-10)

#9-10: Which certifications or licensure, if any, are required for this position?
none = "none" in database
Clarify for each whether a certification or licensure & put in appropriate bucket

#11: In addition to the things you've already mentioned, which specialized skills or knowledge does this position need in order to be effective?

#12: Which tools or technologies does this person use in order to be effective?

#13: As we see a greening of the economy, do you see any trends in new skills or knowledge that you believe will become essential to this position? (if "yes" probe and include answers in a text box.)

SECTION D. SKILL REQUIREMENTS

Next, I'll read a series of skills, for each one please let me know whether that particular skill is necessary for effective job performance in this position. We might have already talked about some of these, but for completeness of our research I need to ask about them again.

#14: Are SUPERVISORY skills necessary to perform this job?
a) Yes
b) No

IF YES: Please provide an example of how this type of skill is applied in this position.

#15: Are project management skills—including budgeting—necessary to perform this job?
a) Yes
b) No

IF YES: Please provide an example of how this type of skill is applied in this position.

#16: Are MATHEMATIC skills necessary to perform this job?
a) Yes
b) No

IF YES: Would you say Basic or Advanced math?

Please provide an example of how this type of skill is applied in this position.

#17: Are TECHNOLOGY DESIGN skills (defined as developing products or adapting equipment and processes to serve user needs) necessary to perform this job?

a) Yes

b) No

IF YES: Please provide an example of how this type of skill is applied in this position.

#18: Are IT professional skills—as opposed to basic computer skills—necessary to perform this job?

a) Yes

b) No

IF YES: Please provide an example of how this type of skill is applied in this position.

#19: Are TECHNICAL skills, which are those used to design, set-up, operate, and correct malfunctions involving application of machines or technological systems, necessary to perform this job? Some examples might include (choose 2-3 examples from the given list).

a) Yes

b) No

If YES: Please provide each relevant skill, and an example of how it is applied in this position.

SECTION E. KNOWLEDGE

This section is similar, but now I'll be asking about knowledge rather than skills. For each knowledge topic, let me know whether knowledge of that area is necessary for effective job performance. Some knowledge areas may be not applicable, which is fine, just let me know if that's the case.

#20: Is LEGAL knowledge (standards, regulations) necessary to perform this job?

a) Yes

b) No

IF Yes: Basic or Advanced? Provide examples.

Appendix III *(continued)*: Green Telephone Script (10-18-10)

#21: Is SCIENCE knowledge (physics, biology, chemistry) necessary to perform this job?

a) Yes
b) No

IF Yes: Basic or Advanced? Provide examples.

#22: Is MECHANICAL knowledge (knowledge of machines and tools, including their designs, uses, repair and maintenance) necessary to perform this job?

a) Yes
b) No

IF Yes: Basic or Advanced? Provide examples.

#23: Is SALES or MARKETING knowledge necessary to perform this job?

a) Yes
b) No

IF Yes: Basic or Advanced? Provide examples.

#24: Is CONSTRUCTION knowledge necessary to perform this job?

a) Yes
b) No

IF Yes: Basic or Advanced? Provide examples.

IF NO 'ADVANCED' KNOWLEDGE AREAS HAVE BEEN IDENTIFIED:

#25: Are there any knowledge areas that are needed at an advanced level to perform this job?

SECTION D. HIRING DIFFICULTIES

#26: Is this a new position or are you replacing someone?

a) New position
b) Existing position
c) Existing position that has been modified {if volunteered}

#27: What is the expected hourly, monthly, or annual compensation?

(Feel free to remind respondent of confidentiality if you think they are uncomfortable with the question. If a range is given, enter the low end of the range and provide detail in the 'Notes' section.)

#28: Has this position been filled?

a) Yes
b) No

#29: Which difficulties, if any, have you had filling the position in terms of the applicant pool?

a) No difficulties.
b) The opening is too new; not sure yet.
c) None or not enough applicants with the *right skills, abilities, or aptitudes*.
d) None or not enough applicants with the right level or type of *formal educational credentials*.
e) None or not enough applicants with the right level or type of *work experience*.
f) None or not enough applicants with the appropriate *certifications or licenses*.
g) Other: _____

IF ITALICIZED ANSWER:

#30: Tell us more about the {***skills / educational /work experience/ licenses***} that you were looking for but not finding for this position.

IF job title listed multiple times—would you have answered the previous questions the same for all (X) of positions?

IF POSITION HAS BEEN FILLED: SECTION E. TRAINING GAPS

#31: First, has the new hire started working yet?

a) Yes
b) No

IF YES ⟶ #32

#32: Have there been any gaps in your new hire's skills, credentials, or background?

a) Yes
b) No

IF YES ⟶ #33 & #34

#33: What are the gaps?

#34: Which of the following steps have you taken to fill these gaps. Have you:

a) Implemented a *formal* internal training program
b) Implemented *informal* internal training (like on-the-job training)
c) Sent the incumbent to an *external* certificate, certification, license, or other degree-granting program
d) Sent the incumbent to an *external program* that does not offer a certificate or degree
e) Asked the incumbent to acquire particular skills/knowledge on their own time
f) Or something else (please tell me what): _____

g) None

If more job openings: START OVER WITH SECTION B.

SECTION F. THANK YOU

"This workforce solution was funded by a grant awarded by the U.S. Department of Labor's Employment and Training Administration. The solution was created by the grantee and does not necessarily reflect the official position of the U.S. Department of Labor. The Department of Labor makes no guarantees, warranties, or assurances of any kind, express or implied, with respect to such information, including any information on linked sites and including, but not limited to, accuracy of the information or its completeness, timeliness, usefulness, adequacy, continued availability, or ownership. This solution is copyrighted by the institution that created it. Internal use by an organization and/or personal use by an individual for non-commercial purposes is permissible. All other uses require the prior authorization of the copyright owner."

POSITIVELY Minnesota

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