Metropolitan Policy Program
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# Methodological Appendix for Sizing the Clean Economy: A National and Regional Green Jobs Assessment

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July 2011

The purpose of the report "Sizing the Clean Economy" is to measure and analyze the jobs associated with the "clean economy" in the United States, its metropolitan areas, and non-metropolitan counties. The goal is to provide timely and detailed information that is relevant to regional economic development leaders, economic analysts, entrepreneurs and business people, trade associations, and policymakers with various levels of geographic focus—namely the regional, state, and national. Metropolitan and rural regional scales are featured because those offer the best statistical approximations of local labor markets. These levels allow for deeper and more actionable analysis for those concerned with the availability of jobs, the training needs of people where they actually live and work, as well as the policies and organizational efforts required to maximize or build upon local strengths.

This methodological appendix supplements the main report by providing detailed information for those wishing to replicate the study, better understand its strengths and weaknesses, or compare it to other studies. Five main issues are addressed:

- How the "clean economy" is defined and categorized in this study, and how that definition compares to other studies
- How clean economy companies were identified across the United States
- How establishments and jobs were counted
- What steps were taken to ensure and improve the reliability and validity of the jobs data, and what known quality limitations exist
- How a further set economic measures were derived, including occupations, wages, exports, industry clusters, and the fossil fuel economy.

[1] This is the external methodological appendix to the 2011 Brookings-Battelle report on the clean economy. See Mark Muro, Jonathan Rothwell, Devashree Saha with Battelle Technology Partnership Practice, "Sizing the Clean Economy: A National and Regional Green Jobs Assessment," (Washington: Brookings Institution, 2011). Please see the acknowledgment section of that report for a long-list of colleagues and partners that helped with this project. For this appendix, the authors are especially indebted to the technical advisory committee.

**Definitional Issues**

This work extends a large body of research at the Brookings Metropolitan Policy Program on the nature of the post-recession U.S. economy, or the emerging "next" economy. Throughout, the program's studies have emphasized and investigated the need to make the U.S. economy cleaner, more innovative, export-oriented, and opportunity rich in order to achieve and sustain broadly shared prosperity.[2] The methodological decisions made in this report follow from those preoccupations in that the focus is on activity that leads to jobs, tradable products, and more efficient resource allocations, while simultaneously accomplishing environmental goals.

A number of challenges arise when trying to delimit economic activity for statistical purposes, such as how to isolate one sector from those that trade with it. To make this enterprise as clear, replicable, and rigorous as possible, three guiding principles were used to define the "clean economy" for this report. Those principles are embedded in the basic definition, which can be summarized as follows:

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

Before elaborating on the definition, readers should know that an establishment is the physical location of a single line of economic activity, such as a factory, store, or office—or a single division within such a location when multiple economic activities take place at the same location. Enterprises (companies, a government, or a nonprofit organization) often have multiple establishments, depending on the size and scope of the enterprise.[3]

The first principle embedded in the above definition is an emphasis on production. What is referred to in the report as the "clean economy" could more descriptively be called the "clean *production* economy," since the report focuses solely on goods and services being produced that are directly associated with clean technologies. In other words, this definition separates out the production-oriented portion of the clean economy from the broader deployment of environmental and energy efficiency processes and advocacy. This means that only jobs related to products that are available for purchase or provided by public sector entities as public goods are considered.[4] Excluded are jobs associated

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[2] "Global Metro Summit 2010: Delivering the Next Economy," available at http://www.brookings.edu/events/2010/1208_metro_summit.aspx; Emilia Istrate, Jonathan Rothwell, and Bruce Katz, "Export Nation: How U.S. Metros Lead National Export Growth and Boost Competitiveness" (Washington: Brookings Institution, 2010).

[3] U.S. Bureau of Labor Statistics, Glossary, http://www.bls.gov/bls/glossary.htm#E.

[4] The U.S. Bureau of Labor Statistics, the chief federal agency for labor market information, is taking the same approach in one of two of its forthcoming surveys on the "green economy." The first survey focuses on jobs associated with production and should overlap considerably with what is reported here, but their

environmental or energy-saving processes or behaviors that are internally adopted by private organizations or implemented by individuals, or what is referred to as clean "process" jobs. Also excluded are jobs related to environmental advocacy (e.g. Greenpeace), general education (e.g. Environmental Science professors) unrelated to specific job training, and scientific research unrelated to product development.[5] These jobs may have important environmental benefits, but in addition to measurement difficulties, they are distantly related to this report's main focus of providing information for economic development.

A second principle is that the products must have an environmental benefit. This requirement has been suggested and its content defined by international statistical agencies.[6] The benefits include preventing, reducing, or minimizing pollution, (including greenhouse gas emissions), or natural resource depletion, or managing natural resources, including energy, for conservation or protection. A more technical definition is discussed below.

The third principle is that establishments add value to clean economy products. To elaborate, companies that directly produce clean technologies or services, like wind turbines, are unambiguously part of the clean economy, but it is less clear how to classify companies that supply parts or services to those clean producers, such as manufacturers of parts for turbines. Some suppliers provide products that are used across industries and purposes (e.g. screws, computer equipment, accounting, financial management), but others make products that are only used in the clean technologies or require skills that are unique to clean technologies (e.g. blades, frames, environmental engineering). The guiding principle used in this study was to only include the establishments of companies that add value to clean products, whether by supplying a part or a service, using skills or technologies that are unique to the clean economy. For example, home weatherization, energy retrofitting, and solar panel installation requires skills that distinguish the services from traditional maintenance work or roofing. The same is true of hybrid-drive assembly in auto-manufacturing plants.

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second survey focuses on process jobs, and will be almost entirely different. More information is available at the BLS website, www.bls.gov/green/.

[5] Jobs in such organizations do not directly contribute to improving or protecting the environment in the same manner as producers of environmental purpose products. Moreover, the services and activities are not sufficiently distinct from advocacy or public education work in other non-environmental fields to qualify as being uniquely environmental or clean economy oriented in nature. Scientific research is a borderline case, but since the potential consequences and applications of the research are uncertain, even for the scientists, and not necessarily "green," it was determined that these are more appropriately thought of as process green jobs, thereby falling outside the scope of this project.

[6] Eurostat, "Handbook on the Environmental Goods and Services Sector" (Luxembourg, 2009); U.S. Census Bureau, "Survey of Environmental Products and Services" (Washington: Environmental Protection Agency, 1998); Organization for Economic Cooperation and Development, "The Environmental Goods and Services Industry: Manual for Data Collection and Analysis," (Paris:, 1999); U.S. Bureau of Labor Statistics Federal Register Notice 75 (182) (September 21, 2010) www.bls.gov/green/frn_2010_09_21.pdf.

A broad overarching goal of this definition was to, whenever possible, adopt standards and definitions previously established by authoritative governmental and quasi-governmental statistical bodies, such as the Organization for Economic Cooperation and Development (OECD), Eurostat (the major European Union statistical office), the U.S. Environmental Protection Agency (EPA), and the U.S. Bureau of Labor Statistics (BLS).[7] The advantage of doing this is that these organizations have devoted considerable time and effort to developing and revising these standards in consultation with a body of experts. Thus, the definition is rigorous and credible. Moreover, as a result of this alignment, the definition used in this report will be more readily comparable to previous and future information.

For example, the forthcoming BLS Green jobs survey will measure production and process jobs in two separate surveys. The first survey uses a definition of "green" jobs that is nearly identical to the one used here; they are:

*"Jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources."* [8]

Adopting international standards also assists in difficult decisions like how to measure clean economy employment once a company is determined to be part of the clean economy. Researchers could decide to only count the jobs associated directly with the production of the clean economy product, excluding the administrative staff, communications staff, executives, maintenance staff and others. Yet, in a firm that makes only clean economy products, all employees add value to its products, and since the goal of this analysis is to study economic activity rather than occupational tasks, these employees are counted. This is essentially the approach recommended by Eurostat. Likewise, the BLS Green Goods and Services survey will use a revenue share as a proxy for green employment. So, if an establishment generates all of its revenue from the sale of green products, then all of its employees will be counted as green employment.[9]

However, if a company earns a significant share of its revenue from non-clean economy products, then an effort was made to count only jobs that add value to its clean economy products. There were two methods used to do this.

First, for very large multi-sector companies, Brookings and Battelle researchers only included a company's establishments that were involved directly in the production of a clean economy product and excluded the establishments that produced alternative products. This was the case for some automobile companies, where clean economy products are not assembled in the same factory as traditional automobiles. For companies that produce only clean economy products, even non-production establishments were included.

[7] Ibid.
[8] BLS Federal Register Notice 75.
[9] BLS, "Measuring Green Jobs," available at http://www.bls.gov/green/.

Second, for large establishments known to produce non-clean economy products, information from company websites and reports were used to estimate the percentage of employees who work on clean economy products versus the percentage who do not. Relevant information included the percentage of revenue earned by the clean economy products and the percentage of products that are part of the clean economy. For example, if a training organization offers five classes but only one is focused on clean economy skills, then one fifth of its staff are counted as employed in the clean economy. This time consuming activity could not have been done for each establishment, and so it was only done for very large establishments or establishments—like community colleges—that were clearly involved in activities outside of the clean economy. This approach is similar but not identical to what the BLS plans on doing in their Green Goods and Services survey. Their strategy will be to multiply the total number of jobs at the establishment by the share of revenue from green goods and services (as defined by BLS).

*Defining an Environmental Benefit*

This study uses the newly updated *Handbook on the Environmental Goods and Services Sector* published by Eurostat to define an environmental benefit, though the handbook uses the word "purpose."[10] The definition states the following:

> An environmental "purpose" (or here "benefit") means that the technology, good or service has the following uses:
>
> - Preventing or minimizing pollution, degradation or natural resources depletion
> - Reducing, eliminating, treating and managing pollution, degradation and natural resources depletion or restoring environmental damage to air, water, waste, noise, biodiversity and landscapes
> - Carrying out other activities such as measurement and monitoring, control, research and development, education, and training related to environmental protection and/or resource management[11]

Brookings and Battelle did not include noise reduction, but otherwise adopted the above definition. The team considered products that significantly increase energy-efficiency, as confirmed by certifications or credible third-party standards, to meet the criteria for both pollution reduction and natural resource conservation, since U.S. energy consumption, in its current and historic form, entails pollution (including green house gas emissions) and the depletion of natural resources. These companies were generally classified in "Energy Efficiency," as discussed below.

[10] Eurostat, "Handbook on the Environmental Goods and Services Sector."
[11] Information and communication were not included and are considered process and not production oriented for these purposes.

The key issue in interpreting a product's "benefit" is whether or not its technical or scientific characteristics allow it to meet one or more of the listed criteria as the product is commonly used. [12] Benefits could be offset by negative consequences, but making such judgments would require detailed scientific studies of every known product, and so the researchers were forced to make their own judgments as informed by previous research from other groups.

As mentioned in the second "guiding principle" listed above, a product does not have to have a direct environmental benefit to be considered part of the clean economy. If the good or service does not have an environmental benefit component but adds value to a good or service that does, it is considered part of the clean economy if and only if it requires a technique or skill distinct from those used to add value to non-clean products.

To illustrate with a few examples, a utility is not included in the clean economy just because it sells electricity to a solar panel manufacturer and therefore adds value to its solar panels. It is only included if it manages and sells energy considered clean, such as hydropower or nuclear power. Returning to the solar example, value is also added to those solar panels by the traditional construction company that helped make the factory and the office furniture suppliers and installers who helped set up the management's offices. Yet, if these jobs were considered part of the clean economy, then there would be no strong justification for excluding anything. Merely trading with a producer of an environmental product is not enough to be considered part of the clean economy.

On the other hand, some suppliers are clearly linked to ultimate producers through specialized knowledge or technologies that are specific to the clean economy. Take the case of a manufacturing plant that specializes in the assembly of cars with fuel-efficient hybrid-drive systems. The work requires that employees have specialized knowledge about those systems, which are substantially different than typical gasoline-driven engines, and so the assembly plant's workers are part of the clean economy despite the fact that the benefit of their economic activity—the assembly of a car from its component parts—is not inherently environmental or resource-saving. Furthermore, the hybrid-system component, by saving oil and moving towards electricity, has a direct environmental benefit and uses uniquely-tailored skills to add value and prepare it for the market, so its associated workers are counted as well.

It warrants noting that industry studies often take a different approach than the one here. Industry studies and those produced by consulting firms will often include something

[12] For example, the EPA adopted the following definition in its environmental economy survey, which was itself related to an earlier Eurostat definition: "This survey is designed to measure the size of the environmental industry. Please report the value of shipments or receipts for products or services you produce, that are used or can potentially be used, for measuring, preventing, limiting, or correcting environmental damage (both natural and man-made) to air, water, soil and the conservation of energy. Also report receipts for services related to the removal, transportation, storage, or abatement of waste, noise and contaminants." U.S. Census Bureau, "Survey of Environmental Products and Services." Randy A. Becker and Ronald J. Shadbegian, "Environmental Products Manufacturing: A Look Inside the Green Industry." *The B.E. Journal of Economic Analysis and Policy* 9 (1) (2009): 1-23.

called "indirect" jobs as part of the clean economy or sector of interest. The analysts admit that these jobs are not directly involved in producing for the sector of interest, but they argue that they are created indirectly through the spending of workers and companies in the clean economy. By this logic, law firms with clean economy clients would be part of the clean economy; computer manufacturers who sell to clean economy producers would be indirectly involved; so would restaurants that serve clean economy employees on their lunch breaks, and so on. As implied by these examples, if adopted, this procedure would have greatly increased the number of jobs deemed part of the clean economy. Yet, it would have been illogical and inaccurate. Every job is an indirect job from the perspective of another industry. For every firm with clean economy clients, there is a firm or consumer that buys from the clean economy. Advocates of the clean economy would hardly want to say that a percentage of solar panel manufacturers are really part of the fossil fuel industry because they buy gasoline to ship their products. For these reasons, only suppliers who make products unique to the clean economy are counted.

*How the "clean economy" was categorized*

An important aspect of any study on the clean economy involves the taxonomy of clean economy jobs it advances. This categorization scheme not only organizes the data after collection, but also guides and motivates the process of collection.

After surveying the literature, the Brookings-Battelle effort ultimately adopted with minor adjustments the categorization scheme proposed by researchers at the U.S. Bureau of Labor Statistics for their forthcoming work (which is set to be released in the spring of 2012).[13] This scheme was chosen because it is sensible and because comparability and standardization add significant value to economic data. The Brookings-Battelle scheme thus consists of five main categories: renewable energy; energy and resource efficiency; greenhouse gas reduction, environmental management, and recycling; agriculture and natural resource conservation; training and compliance.

While those categories are useful, the purpose of the Brookings-Battelle report is primarily to provide detailed and therefore actionable intelligence to metropolitan and local leaders so they can proceed with more informed economic planning strategies. To facilitate that goal, the report develops 39 segments within the five categories. These segments provide a classification system that yields a clearer and more detailed look at the clean economy. They are shown in Table A1, as they line up with the major categories.

The segments were developed by Battelle with input from Brookings. The segment titles and classification system arose naturally from the data as it was being processed. An effort was made to identify the primary clean economy activity for each establishment. Most establishments were generally classified according to the list from which the company's name was drawn (e.g., all establishments included from the American Wind

[13] BLS, "Measuring Green Jobs."

membership list were classified in the Wind segment). When lists were taken from multi-sector sources, the industry code and the type of product provided were considered in classifying the establishment. Some companies and even establishments undoubtedly perform multiple roles either by making more than one clean economy product or by making products that serve multiple environmental functions. While imperfect, the goal was to assign each establishment to a single segment and category based on the most important benefit of its primary product.

**Table A1: Brookings-Battelle Clean Economy Industry Categories and Segments**

| Brookings-Battelle Category (adapted from Bureau of Labor Statistics) | Brookings-Battelle Detailed Segments |
|---|---|
| Agricultural and Natural Resources Conservation | Conservation |
| | Organic Food and Farming |
| | Sustainable Forestry Products |
| Education and Compliance | Regulation and Compliance |
| | Training |
| Energy and Resource Efficiency | Appliances |
| | Battery Technologies |
| | Electric Vehicle Technologies |
| | Energy-saving Building Materials |
| | Energy-saving Consumer Products |
| | Fuel Cells |
| | Green Architecture and Construction Services |
| | HVAC and Building Control Systems |
| | Lighting |
| | Professional Energy Services |
| | Public Mass Transit |
| | Smart Grid |
| | Water Efficient Products |
| Greenhouse Gas Reduction, Environmental Management and Recycling | Air and Water Purification Technologies |
| | Carbon Storage and Management |
| | Green Building Materials |
| | Green Chemical Products |
| | Green Consumer Products |
| | Nuclear Energy |
| | Pollution Reduction |
| | Professional Environmental Services |
| | Recycled-Content Products |
| | Recycling and Reuse |
| | Remediation |
| | Waste Management and Treatment |
| Renewable Energy | Biofuels/Biomass |
| | Geothermal |

| | |
|---|---|
| | Hydropower |
| | Renewable Energy Services |
| | Solar Photovoltaic |
| | Solar Thermal |
| | Waste-to-Energy |
| | Wave/Ocean Power |
| | Wind |

Finally, the easiest way to maximize comparability is to use the industry classification system that is already in place: the North American Industry Classification System (NAICS). Because the data in this system does not distinguish between establishments that have an environmental benefit and those that do not, NAICS does not have detailed enough categories to sort out the clean economy. Yet, each establishment identified by Brookings-Battelle as part of the clean economy does have a six-digit NAICS code identified by Dun and Bradstreet. That code was used to map the clean economy into the more traditional NAICS system in order for researchers to understand how many clean economy jobs are in manufacturing, business services, construction, the public sector, etc.

*How the definition compares to others used in the literature*

The approach described above is consistent with national studies of the clean economy and yielded results that could be considered in the same ball park. Prima facie evidence for this can be seen by comparing the total number of clean economy jobs across studies, as in Table A2. The Brookings-Battelle estimate of 2.7 million jobs is on the high end of a range of estimates but is very close to the upper-bound estimate produced from the U.S. Department of Commerce, which was arguably the most comprehensive and rigorous of the national studies.[14]

**Table A2: Comparison of Total Jobs Across National Clean Economy Studies**

| National Clean Economy Study (Year of Measurement) | Total Clean Jobs | As percent of Brookings 2010 Findings | Share of Clean Jobs in the Economy |
|---|---|---|---|
| Pew/Collaborative Economics (2007) | 769,409 | 29% | 0.6% |
| U.S. Conference of Mayors/Global Insight (2006)[15] | 449,595 | 17% | 0.3% |
| U.S. Department of Commerce (2007) | 1,821,000 - 2,382,000 | 68% to 89% | 1.4% - 1.8% |

[14] As listed, not all of these studies measure the same year. In 2007, the Brookings-Battelle number was 2.4 million, for comparison.

[15] U.S. Conference of Mayors, "U.S. Metro Economies: Current and Potential Green Jobs in the U.S. Economy" (2009).

| | | | |
|---|---|---|---|
| U.S. International Trade Administration (2008)[16] | 1,700,000 | 64% | 1.3% |
| Brookings-Battelle (2010) | 2,675,545 | - | 2.0% |

To elaborate, the Department of Commerce's report, "Measuring the Green Economy" was similar to the Brookings-Battelle study in that it both excluded process jobs and limited the scope to jobs associated with "green" (or clean economy) products.[17] The Commerce researchers then estimated the number of jobs associated with each product that it deemed part of the "green economy." By using a product based method, the researchers overcame difficulties of survey design and company identification. Their list of products can also be read and critiqued by researchers and goes far to advance the study of the clean economy. The major limitation of the Commerce method is that it does not provide any sub-national data. It also offers little detail beyond high-level categorizations.

Another major study in this field was conducted by The Pew Charitable Trust in their 2009 report entitled "The Clean Energy Economy." Like the Brookings-Battelle study it also focused on production activities, but unlike the Brooking-Battelle study, it omits public sector conservation and regulation, nuclear energy, and public transportation services, among other segments.[18] Comparing aggregate numbers, the Pew report arrived at a total number of jobs that is just under one-third of the Brookings-Battelle estimate (the gap is similar but slightly less when 2007 data is compared). This is likely the result of methodological differences, but not only those related to segment choice (the Brookings-Battelle database has 1.8 million jobs outside of the segments excluded by Pew). The Brookings-Battelle report used the same list of SICs identified by Pew researchers as completely clean but added another larger group of SIC codes developed more recently by researchers at Berkeley.[19] Moreover, while the Pew team used an internet-based search method to identify companies beyond those SICs, Brookings-Battelle identified companies using member lists, certifications, grantees, and many other sources, as described below.

There are also a growing number of state and regional studies wrestling with the question of what is a "clean" or "green" industry. These state and local studies have typically focused on the new wave of renewable energy development, whether it be the economic

[16] U.S. International Trade Administration, Office of Energy and Environmental Industries, "Environmental Technologies Industries: 2010 Industry Assessment" (2010).
[17] U.S. Department of Commerce, Economics and Statistics Administration "Measuring the Green Economy" (Washington, 2010).
[18] Pew Charitable Trusts, "The Clean Energy Economy: Repowering Jobs, Business and Investment Across America" (Washington, 2009). The Pew report also included a few activities that would not meet the definition used here because the companies' products lack an environmental use and do not require skills specific to the clean economy. These activities include finance (other than specialized venture capital), accounting, legal services, marketing, public relations, and staffing services. Such services may add value to clean economy products, but they could just as easily add value to other products, unless they take place within a company that specializes in a product with an environmental use.
[19] The Center for Community Innovation, "Innovating the Green Economy in California Regions" (2010).

activities to advance technologies and generate renewable energy (i.e., wind, solar, biomass, etc.) or to address enabling technologies that are critical to advancing the mainstream use of these new renewable energy sources (i.e., energy storage, grid technologies, etc.). But there are still variations across the studies, and there is no widely acknowledged definition of the industries that comprise the green economy.

For example, activities that are deemed "clean energy" are excluded in some studies because they are not renewable. Jobs in nuclear energy production were not included in the Pew report, nor are they typically included in state and regional studies because of environmental difficulties related to the storage of spent nuclear fuel, waste, and various by-products. While the storage issue presents a serious environmental and human challenge, the Brookings-Battelle team decided to include nuclear energy-related jobs primarily because of the technology's carbon-reducing effects (though users can always choose to remove the segment when conducting their own analyses with the Brookings-Battelle data, available online). Moreover, the potentially harmful effects of nuclear waste must be compared to the harmful effects of material extraction for other technologies. A report by the European Commission rated nuclear energy as having less costly life-cycle consequences for the environment than current solar energy technologies, and far less than fossil fuel-based approaches.[20]

Both this report and the Pew study include carbon storage and management technology related to coal technology, which could dramatically reduce the effects of coal emissions on global warming, even if other environmental damage from coal remains significant. This technology can be thought of along the lines of retrofits for vehicle exhausts; in both cases, a mitigation of the harmful effects of an inherently harmful activity offers a second best solution.

The definition used in this report also differs substantially from state-specific occupational reports being produced by many state labor market information offices. These occupational reports survey all businesses to identify both the number of production and process jobs, but may miss jobs that do not have explicit environmental purposes, even if they add value to environmental products.[21] That is, the surveys ask employers to list jobs in their firm that have environmental functions, but employers might not consider that their products use unique skills to supply parts to environmental products. On the other hand, employers may include jobs in companies that do not sell clean economy products, but have employees whose primary job function involves increasing internal energy efficiency or reducing the company's own pollution. So, this research strategy is more likely to accurately measure jobs that have environmental goals, while the Brookings-Battelle strategy is arguably more likely to accurately measure jobs that add value to clean economy products.

[20] European Commission, "External Costs: Research Results on Socio-environmental Damages Due to Electricity and Transport" (2003).
[21] States include Washington, Michigan, Connecticut, Kansas, Missouri, and Oregon. See below for references.

At the state level, the number of clean economy jobs reported in this count tends to slightly exceed that reported by various state survey estimates. The present count runs between 12 and 25 percent higher than the total number of jobs estimated by state government surveys in Oregon, California, and Connecticut.[22] Estimates by a state agency for Washington in 2008 were roughly half of the Brookings estimates but after a methodological change the 2009 edition of the survey yielded a jobs number 19 percent higher than the Brookings-Battelle estimates.[23] Two states—Missouri and Kansas—came up with "direct job" estimates that were one-third to one-fourth lower than the Brookings-Battelle figures.[24] Michigan was the only state with a major green jobs survey that produced a substantially higher number than the Brookings-Battelle employment estimate.[25] There, the Brookings-Battelle estimate came in about 30 percent lower than the Michigan number. Finally, a study of 11 large counties in California by researchers at the University of California at Berkeley located 110,000 clean economy jobs in those counties—a figure that compared with a Brookings-Battelle figure of 169,000 for the same counties.[26]

The Brookings team also compared job levels in this database to industry reports. In almost every case, the total number of jobs reported by the industry was higher if "indirect" jobs were counted, which, for reasons stated above, should not be. When direct jobs are compared, the Brookings numbers are much closer. The Solar Energy Industries Association has estimated 24,000 direct jobs in the solar industry.[27] This number is slightly lower than the 29,531 estimated by Brookings. The Solar Foundation, in conjunction with Green LMI, did a survey suggesting that there were 93,502 solar energy jobs (mostly in California) but only 24,916 jobs in solar manufacturing.[28] This comparison reveals that the Brookings-Battelle estimates probably undercounted jobs in solar installation; those workers are difficult to measure because the work can also be done by companies that are heavily involved in traditional construction and installation activities. The National Hydropower Association estimated 60,000 direct jobs, compared

[22]The Oregon Employment Department, "The Greening of Oregon's Workforce: Jobs, Wages, and Training" (2009); California Employment Development Department, "California's Green Economy," (2010); Nicholas Jolly, "How Green is Connecticut's Economy?" *The Connecticut Economic Digest* 13 (12) (2008): 1-3. The green jobs number in California refers to the number of employees who report spending most of their time on green aspects of job (263,000).

[23] Washington State Employment Security Department, "2008 Washington State Green Economy Jobs" (2009); Washington State Employment Security Department, "2009 Washington State Green Economy Jobs" (2010).

[24] Missouri Economic Research and Information Center, "The Missouri Green Jobs Report" (2009); Kansas Department of Labor, "2009 Kansas Green Jobs Report" (2010).

[25] Michigan Department of Energy, Labor & Economic Growth, "Michigan Green Jobs Report: Occupations & Employment in the New Green Economy" (2009).

[26] Pew, "The Clean Energy Economy"; Department of Commerce, "Measuring the Green Economy;" International Trade Administration, "Environmental Technologies Industries: 2010 Industry Assessment;" U.S. Conference of Mayors, "U.S. Metro Economies: Current and Potential Green Jobs;" Center for Community Innovation, "Innovating the Green Economy in California Regions.".

[27] Solar Energy Industries Assocation, available at www.seia.org.

[28]The Solar Foundation, available at http://www.thesolarfoundation.org/.

to 55,433 estimated by Brookings-Battelle.[29] The American Wind Energy Association estimates 30,000 direct jobs; Brookings-Battelle estimates 24,294 wind jobs.[30] Finally, the Geothermal Energy Association estimates 9,000 direct jobs, while the Brookings-Battelle figure is 2,720.[31] Overall, while not perfect matches, these comparisons suggest the database presented here is fairly reliable, though coverage of solar installers may be incomplete.

**Identifying Firms Involved in the Clean Economy**

With the definition established, the next step was to identify companies in the clean economy for each segment and category. In economic studies of well-established sectors—like the oil and gas sector or the biotech sector—publicly available data can be re-arranged and analyzed with little difficulty. However, this approach is not possible when studying the clean economy, in part because components of it are new and relatively small, and, in part, because it is distributed across many traditional industries. As the BLS explains in the March 16, 2010 Federal Register Notice, "The studies reviewed showed that neither of the standard classification systems used in the BLS data, NAICS and the Standard Occupational Classification (SOC), identifies a green or environmental grouping of industries or occupations."[32]

To overcome this challenge, two steps were taken. First, a set of industries were identified as being exclusively part of the clean economy using the eight-digit SIC (Standard Industrial Classification) system developed by the business intelligence firm Dun and Bradstreet (D&B) and maintained as a time series by Walls and Associates as the National Establishment Time Series (NETS).[33] To develop this list, the Brookings-Battelle team drew from two previous studies from the Pew Charitable Trusts and the University of California at Berkeley. Using NETS data, researchers at Collaborative Economics developed for Pew a list of roughly 70 eight-digit SIC codes that could be considered to be fully part of the clean economy.[34] Berkeley researchers worked off that list and added over 100 new SICs to it.[35] The Brookings-Battelle team carefully evaluated these codes and adopted almost all of them, depending on whether or not they met the

[29] National Hydropower Association, available at http://hydro.org/.
[30] American Wind Energy Assoication, available at http://www.awea.org/.
[31] Geothermal Energy Association, available at http://geo-energy.org/geo_basics_employement.aspx.
[32] See www.gpo.gov/fdsys/pkg/FR-2010-03-16/pdf/2010-5705.pdf
[33] Since 1990, the firm Dun and Bradstreet has aimed to create a census of U.S. establishments and their employees. They originally used the SIC system to classify firms, and found that they needed to expand the number of digits from six to eight to account for new industries. In 1997, the federal government moved to the NAICS, but Dun and Bradstreet kept the older system that they had developed. Walls and Associates has developed a cross-walk between D&B's SIC codes and modern day NAICS, which was used in this report.
[34] The Pew Charitable Trusts, "The Clean Energy Economy." Pew found that 60 percent of clean economy jobs are in establishments from these industries.
[35] Karen Chapple and Malo Hutson, "Innovating the Green Economy in California Regions" (Berkeley: University of California Center for Community Innovation, 2010), available at http://communityinnovation.berkeley.edu/publications.html.

stated definition above.[36]
Public mass transportation, for example, was included because engineering research by the Department of Transportation finds that buses require just 76 percent of the amount of energy per passenger mile as passenger cars, and rail travel requires only 50 percent.[37]

After this SIC code-checking process, companies that were clearly mis-classified were dropped (e.g. taxi services listed as school bus providers), and the rest included. Furthermore, an additional 45 SICs were added to encompass air, water, and solid waste management establishments in the public and private sector. In the end, 222 SICs were included as fully part of the clean economy, barring misclassifications. This list is presented in full in Table A3 along with the number of jobs and establishments associated with each micro-industry. These industries eventually made up 68.9 percent of establishments, but only 49.0 percent of clean economy jobs.[38]

**Table A3. List of Standard Industry Codes (SICs) developed by Dun and Bradstreet considered to be fully part of the Clean Economy, except when establishments were miscoded**

| SIC | SIC title | Establishments in database | Jobs in database, 2010 |
|---|---|---|---|
| 1810103 | Mats, preseeded: soil erosion, growing of | 20 | 217 |
| 8510102 | Reforestation services | 111 | 3545 |
| 13110201 | Coal gasification | 7 | 190 |
| 16290505 | Waste water and sewage treatment plant construction | 201 | 6730 |
| 17110403 | Solar energy contractor | 318 | 4675 |
| 17310101 | Cogeneration specialization | 12 | 787 |
| 17310202 | Energy management controls | 80 | 4250 |
| 17310203 | Environmental system control installation | 45 | 1230 |
| 17420203 | Insulation, buildings | 1856 | 36217 |
| 17420204 | Solar reflecting insulation film | 17 | 139 |
| 17819901 | Geothermal drilling | 45 | 744 |
| 17969906 | Pollution control equipment installation | 23 | 484 |
| 17990208 | Insulation of pipes and boilers | 197 | 7210 |
| 17990210 | Weather stripping | 14 | 181 |

[36] The following SIC were excluded from this list by Brookings-Battelle because they were not deemed fully part of the clean economy: fur cutting and scraps, bicycle assembly service, bicycle repair shop, urban planning, and city planning. In some cases—urban planning—a few establishments found their way into the database through the other identification step (e.g. membership, certification, etc).

[37] U.S. Department of Transportation Research and Innovative Technology Administration at the Bureau of Transportation Statistics, "2011 National Transportation Statistics" (2011), available at http://www.bts.gov/publications/national_transportation_statistics/.

[38] The percentage of jobs in the Brookings-Battelle database that came from the 177 "all clean" SICs that were also identified as fully clean by the Berkeley researchers (which includes those used by the Pew team) was 29.7 percent. Moreover, 48.7 percent of establishments came from the SICs on this list.

| | | | |
|---|---|---|---|
| 17990800 | Decontamination services | 171 | 4759 |
| 17990801 | Asbestos removal and encapsulation | 736 | 18254 |
| 24930400 | Insulation and roofing material, reconstituted wood | 20 | 2929 |
| 28210401 | Carbohydrate plastics | 2 | 259 |
| 28210407 | Soybean plastics | 1 | 5 |
| 28690104 | Ethyl alcohol, ethanol | 120 | 4475 |
| 28739901 | Fertilizers: natural (organic), except compost | 102 | 2388 |
| 28759901 | Compost | 65 | 1021 |
| 28999913 | Desalter kits, sea water | 1 | 10 |
| 28999928 | Insulating compounds | 20 | 540 |
| 28999948 | Water treating compounds | 184 | 4961 |
| 32110302 | Insulating glass, sealed units | 36 | 2374 |
| 32310401 | Insulating glass: made from purchased glass | 34 | 2205 |
| 34339904 | Solar heaters and collectors | 65 | 3038 |
| 34430304 | Economizers (boilers) | 2 | 27 |
| 35110207 | Wheels, water | 2 | 34 |
| 35239906 | Windmills for pumping water, agricultural | 5 | 40 |
| 35590403 | Desalination equipment | 10 | 2139 |
| 35599937 | Recycling machinery | 74 | 1228 |
| 35640101 | Air cleaning systems | 60 | 1344 |
| 35640102 | Air purification equipment | 127 | 3323 |
| 35890300 | Sewage and water treatment equipment | 168 | 3781 |
| 35890301 | Sewage treatment equipment | 34 | 809 |
| 35890302 | Sewer cleaning equipment, power | 22 | 499 |
| 35890304 | Water filters and softeners, household type | 101 | 2346 |
| 35890305 | Water purification equipment, household type | 118 | 2922 |
| 35890306 | Water treatment equipment, industrial | 415 | 10303 |
| 35899901 | Asbestos removal equipment | 8 | 280 |
| 35999919 | Water leak detectors | 22 | 240 |
| 36130210 | Regulators, power | 4 | 1396 |
| 36210116 | Storage battery chargers, motor and engine generator type | 2 | 12 |
| 36219909 | Windmills, electric generating | 31 | 1099 |
| 36290101 | Battery chargers, rectifying or nonrotating | 33 | 1624 |
| 36290102 | Electrochemical generators (fuel cells) | 5 | 263 |
| 36290107 | Thermo-electric generators | 4 | 68 |
| 36410106 | Lamps, fluorescent, electric | 9 | 792 |
| 36459905 | Fluorescent lighting fixtures, residential | 13 | 897 |
| 36469904 | Fluorescent lighting fixtures, commercial | 44 | 2705 |
| 36740305 | Photovoltaic devices, solid state | 18 | 666 |
| 36740306 | Solar cells | 47 | 4603 |

| | | | |
|---|---|---|---|
| 36749901 | Fuel cells, solid state | 14 | 562 |
| 36919902 | Batteries, rechargeable | 39 | 2540 |
| 36940100 | Battery charging alternators and generators | 9 | 161 |
| 36940102 | Battery charging generators, automobile and aircraft | 5 | 77 |
| 37110104 | Cars, electric, assembly of | 11 | 484 |
| 38220000 | Environmental controls | 199 | 10678 |
| 38220206 | Temperature controls, automatic | 55 | 1982 |
| 38220300 | Thermostats and other environmental sensors | 14 | 529 |
| 38220301 | Built-in thermostats, filled system and bimetal types | 2 | 1350 |
| 38220304 | Temperature sensors for motor windings | 6 | 221 |
| 38220305 | Thermocouples, vacuum: glass | 1 | 225 |
| 38220306 | Thermostats, except built-in | 7 | 268 |
| 38229901 | Building services monitoring controls, automatic | 53 | 1777 |
| 38229904 | Electric air cleaner controls, automatic | 8 | 305 |
| 38229905 | Energy cutoff controls, residential or commercial types | 16 | 536 |
| 38229917 | Water heater controls | 5 | 49 |
| 38230506 | Water quality monitoring and control systems | 110 | 2693 |
| 38240114 | Totalizing meters, consumption registering | 1 | 120 |
| 38240117 | Water meters | 24 | 2055 |
| 38250303 | Current measuring equipment, nec | 4 | 64 |
| 38250304 | Demand meters, electric | 1 | 15 |
| 38250305 | Electrical power measuring equipment | 17 | 847 |
| 38250306 | Energy measuring equipment, electrical | 14 | 298 |
| 38260700 | Instruments measuring thermal properties | 10 | 482 |
| 38269907 | Environmental testing equipment | 68 | 1891 |
| 38290218 | Solarimeters | 3 | 42 |
| 38290701 | Temperature sensors, except industrial process and aircraft | 15 | 335 |
| 38290702 | Thermocouples | 12 | 326 |
| 40119902 | Interurban railways | 6 | 6850 |
| 40139904 | Railroad terminals | 1 | 17 |
| 41110000 | Local and suburban transit | 730 | 52315 |
| 41110100 | Bus transportation | 286 | 13378 |
| 41110101 | Bus line operations | 213 | 39422 |
| 41110102 | Commuter bus operation | 23 | 2598 |
| 41110200 | Street and trolley car transportation | 13 | 269 |
| 41110201 | Streetcar operation | 5 | 140 |
| 41110202 | Trolley operation | 9 | 493 |
| 41110400 | Passenger rail transportation | 23 | 3684 |
| 41110401 | Commuter rail passenger operation | 23 | 11624 |
| 41110402 | Local railway passenger operation | 12 | 2113 |

| | | | |
|---|---|---|---|
| 41110403 | Subway operation | 19 | 5386 |
| 41119901 | Cable cars, except aerial, amusement, and scenic | 1 | 30 |
| 41119903 | Monorails, regular route: except amusement and scenic | 1 | 400 |
| 41190000 | Local passenger transportation, nec | 1036 | 30613 |
| 41199906 | Vanpool operation | 60 | 2176 |
| 41310000 | Intercity and rural bus transportation | 431 | 19176 |
| 41319901 | Intercity bus line | 112 | 11197 |
| 41319902 | Intercity highway transport, special service | 23 | 810 |
| 41319903 | Interstate bus line | 35 | 2451 |
| 41730000 | Bus terminal and service facilities | 68 | 4226 |
| 41739901 | Bus terminal operation | 63 | 2203 |
| 42129906 | Garbage collection and transport, no disposal | 855 | 21921 |
| 42129907 | Hazardous waste transport | 162 | 4333 |
| 44890000 | Water passenger transportation | 16 | 207 |
| 47290102 | Bus ticket offices | 28 | 748 |
| 47299901 | Carpool/vanpool arrangement | 56 | 1939 |
| 47890200 | Passenger train services | 26 | 695 |
| 47890400 | Railroad maintenance and repair services | 1 | 450 |
| 49520000 | Sewerage systems | 1095 | 29978 |
| 49530000 | Refuse systems | 1517 | 45965 |
| 49530100 | Hazardous waste collection and disposal | 333 | 10836 |
| 49530101 | Acid waste, collection and disposal | 6 | 514 |
| 49530102 | Chemical detoxification | 14 | 724 |
| 49530103 | Radioactive waste materials, disposal | 14 | 1206 |
| 49530200 | Refuse collection and disposal services | 1106 | 29204 |
| 49530201 | Garbage: collecting, destroying, and processing | 551 | 20132 |
| 49530202 | Liquid waste, collection and disposal | 99 | 2257 |
| 49530203 | Rubbish collection and disposal | 537 | 17341 |
| 49530204 | Street refuse systems | 52 | 1838 |
| 49530300 | Nonhazardous waste disposal sites | 105 | 3583 |
| 49530301 | Dumps, operation of | 53 | 1916 |
| 49530302 | Sanitary landfill operation | 667 | 14116 |
| 49530303 | Sludge disposal sites | 16 | 383 |
| 49539901 | Ashes, collection and disposal | 19 | 295 |
| 49539902 | Dead animal disposal | 16 | 263 |
| 49539903 | Incinerator operation | 24 | 739 |
| 49539904 | Medical waste disposal | 124 | 3201 |
| 49539905 | Recycling, waste materials | 2691 | 51015 |
| 49539906 | Waste materials, disposal at sea | 23 | 424 |
| 49539907 | Sewage treatment facility | 203 | 3808 |

| | | | |
|---|---|---|---|
| 49590000 | Sanitary services, nec | 381 | 7965 |
| 49590300 | Toxic or hazardous waste cleanup | 83 | 4299 |
| 49590301 | Oil spill cleanup | 59 | 1090 |
| 49590302 | Environmental cleanup services | 447 | 12109 |
| 50330200 | Insulation materials | 249 | 4599 |
| 50330201 | Fiberglass building materials | 63 | 1360 |
| 50330202 | Insulation, thermal | 107 | 1957 |
| 50330203 | Mineral wool insulation materials | 3 | 158 |
| 50399912 | Soil erosion control fabrics | 66 | 1081 |
| 50740102 | Water purification equipment | 330 | 4548 |
| 50740200 | Heating equipment (hydronic) | 346 | 5425 |
| 50740208 | Heating equipment and panels, solar | 53 | 906 |
| 50750103 | Air pollution control equipment and supplies | 65 | 1119 |
| 50750205 | Thermostats | 24 | 749 |
| 50840704 | Meters, consumption registering | 48 | 570 |
| 50840706 | Pollution control equipment, air (environmental) | 74 | 977 |
| 50840707 | Pollution control equipment, water (environmental) | 42 | 652 |
| 50849914 | Recycling machinery and equipment | 115 | 1800 |
| 50930000 | Scrap and waste materials | 654 | 13620 |
| 50930100 | Waste paper and cloth materials | 26 | 570 |
| 50930101 | Bag reclaiming | 3 | 49 |
| 50930102 | Boxes, waste | 4 | 252 |
| 50930103 | Fur cuttings and scraps | 1 | 5 |
| 50930104 | Textile waste | 42 | 912 |
| 50930105 | Waste paper | 233 | 6196 |
| 50930106 | Waste rags | 32 | 1384 |
| 50930200 | Metal scrap and waste materials | 768 | 14135 |
| 50930201 | Ferrous metal scrap and waste | 627 | 15233 |
| 50930202 | Nonferrous metals scrap | 223 | 4995 |
| 50930203 | Wire and cable scrap | 5 | 58 |
| 50939901 | Automotive wrecking for scrap | 449 | 5574 |
| 50939902 | Barrels and drums | 9 | 68 |
| 50939903 | Bottles, waste | 9 | 127 |
| 50939904 | Junk and scrap | 132 | 1652 |
| 50939905 | Oil, waste | 59 | 1352 |
| 50939906 | Plastics scrap | 49 | 1031 |
| 50939907 | Rubber scrap | 14 | 216 |
| 50939908 | Scavengering | 1 | 12 |
| 50939909 | Lumber scrap | 3 | 52 |
| 52110300 | Insulation and energy conservation products | 40 | 502 |

| | | | |
|---|---|---|---|
| 52110301 | Energy conservation products | 68 | 923 |
| 52110302 | Insulation material, building | 71 | 1344 |
| 52110303 | Solar heating equipment | 80 | 1094 |
| 73890201 | Air pollution measuring service | 69 | 1133 |
| 73899931 | Meter readers, remote | 42 | 1614 |
| 76990304 | Thermostat repair | 2 | 19 |
| 81110208 | Environmental law | 52 | 727 |
| 86419903 | Environmental protection organization | 877 | 14821 |
| 87110100 | Sanitary engineers | 45 | 1103 |
| 87110101 | Pollution control engineering | 110 | 3326 |
| 87110403 | Heating and ventilation engineering | 125 | 2214 |
| 87119906 | Energy conservation engineering | 217 | 4806 |
| 87310300 | Natural resource research | 6 | 282 |
| 87310301 | Energy research | 291 | 29038 |
| 87310302 | Environmental research | 364 | 10677 |
| 87340300 | Pollution testing | 66 | 1433 |
| 87340301 | Hazardous waste testing | 38 | 1099 |
| 87349909 | Soil analysis | 132 | 3030 |
| 87349911 | Water testing laboratory | 223 | 6254 |
| 87449904 | Environmental remediation | 471 | 11555 |
| 87480200 | Urban planning and consulting services | 8 | 394 |
| 87480201 | City planning | 1 | 55 |
| 87489904 | Energy conservation consultant | 541 | 10079 |
| 87489905 | Environmental consultant | 4211 | 81085 |
| 89990703 | Natural resource preservation service | 474 | 6308 |
| 95110000 | Air, water, and solid waste management | 1121 | 98700 |
| 95110100 | Environmental agencies | 113 | 10865 |
| 95110101 | Air pollution control agency, government | 61 | 4881 |
| 95110102 | Environmental protection agency, government | 184 | 38761 |
| 95110103 | Environmental quality and control agency, government | 69 | 4000 |
| 95110200 | Waste management agencies | 185 | 7485 |
| 95110201 | Sanitary engineering agency, government | 78 | 4646 |
| 95110202 | Waste management program administration, government | 284 | 20591 |
| 95110203 | Water control and quality agency, government | 512 | 25009 |
| 95110204 | Water pollution control agency, government | 95 | 4717 |
| 95110400 | Air, water, and solid waste management, level of government | 3 | 54 |
| 95110401 | Air, water, and solid waste management, Federal government | 6 | 188 |
| 95110402 | Air, water, and solid waste management, State government | 19 | 547 |
| 95110403 | Air, water, and solid waste management, County government | 180 | 6133 |
| 95110404 | AIr, water, and solid waste management, Local government | 567 | 27053 |

| | | | |
|---|---|---|---|
| 95120100 | Wildlife conservation agencies | 121 | 10778 |
| 95120200 | Land conservation agencies | 716 | 35047 |
| 95120201 | Land management agency, government | 237 | 14877 |
| 95120203 | Wind and water erosion control agency, government | 8 | 238 |
| 95120403 | Land, mineral, and wildlife conservation, County government | 69 | 1986 |
| 95120404 | Land, mineral, and wildlife conservation, Local government | 93 | 4752 |
| 96319905 | Nuclear energy inspection and regulation office, govt. | 12 | 3429 |
| 96319908 | Sanitary district: nonoperating, government | 21 | 2480 |

The second step—used to build the rest of the database—was to gather company names from validated lists of clean economy firms. This approach significantly broadened the industry coverage and ensured that many of the most important firms in the clean economy were incorporated. A wide range of data sources were used to generate the list of lists. The Brookings-Battelle team examined members of business and industry organizations; recipients of clean economy venture capital; inventors of clean economy patents; firms with government or third-party certifications for green products; and federal grant winners for green services like solar installation training or green research and development projects funded by the Department of Energy. The team also considered and incorporated listings from market research organizations. Finally, a number of broad multi-segment proprietary data sources were examined to better ensure comprehensive coverage. These sources included the Environmental Business Journal; Plunkett's Renewable, Alternative and Hydrogen Energy Industry database; and the CorpTech technology company database. Table A4 shows the master list—in other words, the key sources used to identify clean economy firms for this study.

It is important to note that many firms are included in multiple lists, certain lists may include firms from multiple segments, and some lists may only yield a few additional firms for a segment. It should also be noted that not all firms included in these lists could be found within the Dun and Bradstreet dataset used to develop the Brookings-Battelle clean economy dataset.

**Table A4: National Sources Examined to Identify Clean Economy Firms**

| *Specialized Listings Examined* |
|---|
| • Environmental Business Journal/Climate Change Business Journal<br>• Plunkett's Renewable, Alternative and Hydrogen Energy Industry<br>• CorpTech<br>• "Green" and "Clean" Venture Capital Index(s)<br>• Venture Capital Information Related to Renewable Energy and Environmental Technologies/Services<br>• Recently Received Patents Related to Renewable Energy and Environmental Technologies/Services<br>• Registered Ethanol/Biodiesel Production Locations<br>• Various Market Studies from BCC Research, Frost and Sullivan, Freedonia |

- Hybrid/Electric Automotive and Heavy Vehicle Manufacturers and Suppliers
- Private and Public "Clean Economy" and "Mass Transit" (including Amtrak/Nat'l Passenger Rail Corp.) lists using D& B 8-digit SICs

***Certifications Examined***

- DOE -Office of Energy Efficiency and Renewable Energy Grantees
- DOE -ARPA-E Grantees
- DOE/EPA Energy Star - Installers/Services
- DOE/EPA Energy Star - Products/Manufacturers
- DOE/HUD Weatherization Assistance Program Subcontractors of Grantees
- DOE Energy Efficiency and Conservation Block Grants Subcontractors of Grantees
- EPA Smart Way
- EPA WaterSense
- EPA Design for the Environment (DfE)
- EPA Comprehensive Procurement Guidelines (CPG)
- USDA BioPreferred
- USDA National Organic Farms and Food Certification Program
- USDA Rural Energy for America Program (REAP)
- Underwriters Laboratory (UL) Sustainable/Environmental/Energy Efficiency Product Certifications and Verifications
- Building Green (GreenSpec)
- Sustainable Forestry Initiative (SFI) Certification
- Forest Stewardship Council Recycled Material Certification
- Composite Panel Association Environmentally Preferable Products (EPP)
- Carpet and Rug Institute Cleantech Label/Cleantech Label Plus Certification
- National Association of Home Builders "NAHBGreen" and "Green Approved" Certifications
- Level: Business and Institutional Furniture Manufacturers Association (BIFMA) Certification
- California Recycled Content (incl. firms outside of California)
- Cool Roof Rating Council Certification
- Electronic Product Environmental Assessment Tool (EPEAT) Cleantech Electronics Council Certification
- Cleantech Seal (Third Party) Certification
- GoodGuide (Third Party) Certification[39]
- SCS (Third Party) FloorScore Certification
- GREENGUARD (Third Party) Environmental Institute (Third Party) Certification
- SCS (Third Party) Indoor Advantage and Indoor Advantage Gold Certifications
- SCS (Third Party) Environmentally Preferable Products
- MBDC (Third Party) Cradle to Cradle Certification
- MTS (Third Party) SMART Certification

[39] In this report, companies were identified as part of the clean economy if they make a products with an environmental score of 8.0 or higher (out of 10) on GoodGuide in April of 2010. For some product categories, the environmental score was based entirely on company data rather than product data; for others 25 percent to 75 percent of the product score comes from specific product information. The authors would like to thank GoodGuide for sending Brookings a list of every company with a product that met that the criterion. Details can be found here: http://www.goodguide.com/about/ratings (2011).

- Solar Rating and Certification Corp. (Third Party) Certification
- Sustainable Attributes Verification and Evaluation (SAVE) ICC Evaluation Service (Third Party) Certifications
- Companies involved in LEED Certified Projects
- Mechanical Service Contractors of America Green Star Certification
- Building Performance Institute Gold Star Standard

***National Associations Examined***

- American Council on Renewable Energy (ACORE)
- American Solar Energy Society (ASES)
- American Wind Energy Association (AWEA)
- BioEnergy Producers Association
- Biomass Thermal Energy Council (BTEC)
- Geothermal Energy Association (GEA)
- Geothermal Resources Council (GRC)
- Gridwise Alliance
- Growth Energy
- National Association of Energy Service Companies (NAESCO)
- National Hydrogen Association (NHA)
- National Hydropower Association (NHA)
- Renewable Fuels Association (RFA)
- Solar Electric Power Association (SEPA)
- Solar Energy Industries Association (SEIA)
- United States Clean Heat and Power Association (USCHPA)
- United States Fuel Cell Council (USFCC)
- USA Biomass Power Association (US BPA)

Establishing this master list was probably the most difficult and consequential methodological decision made by the research team. The goal was to be as comprehensive as possible without exaggerating the extent of the clean economy. Since this is a national study with tens of thousands of firms, the Brookings-Battelle team did not have the luxury of investigating every firm individually to see if it would meet the definition laid out above. Therefore, the lists had to have meaningful barriers to entry. In that vein, it is worth discussing some lists that did not make it into our study:

- The U.S. Green Building Council: Membership is open to anyone for a fee of as little as $300 a year, depending on the size of the company and its industry—without having to fulfill any environmental criteria. Even if all of the members are legitimately concerned with the environment, many of the members would fall into the green *process* economy (described above) but not the clean *production* economy. That is, companies not selling products that have an environmental benefit, but rather trying to reduce their own negative impact on the environment by improving internal operations. It was clear after sampling some of these firms, that many would not meet our standard, unless they were involved directly in LEED-certified projects, which was used as a separate criterion. Also, many of

the product companies included in the USGBC list entered into the Brookings-Battelle dataset through other list sources.

- Participation in green trade shows: While trade shows offer companies a chance to showcase their innovative products, attendees—and even presenters—are not necessarily producers of clean economy products.

- Prime recipients of government contracts for green programs (such as for home weatherization or training for solar panel installation): Many prime recipients are government agencies or non-profit organizations that coordinate clean economy activity, as part of their many responsibilities, but do not directly participate in it and do not meet our definition as being part of the clean economy. Here the sub-prime contractors are the party of interest.

To further illustrate how the lists were used, Table A5 shows which lists were assigned to each of the segments. Where the list states "Industry Codes and D&B Product Info," establishments were included if listed under a relevant NAICS or eight-digit SIC code developed by D&B. For example, all records under NAICS 4851 (Urban Transit Systems) were included under public mass transit. However, D&B occasionally miscodes the industry of some establishments so company names and business activity descriptions were also examined. For example, some limousine services, which were not considered part of the clean economy, were included in Urban Transit Systems and had to be excluded manually by searching for "limousine." This is just one example of how the quality of the segments and the overall database was maintained.

Table A5 also lists a description of the segment according to the detailed NAICS industries of the establishments that comprise it. This gives the reader a sense of how the clean economy segments correspond to the traditional economy. To be clear, in most cases, only a small percentage of the establishments in the industries listed in the second column were included in the clean economy database, since firms, from whichever industry, had to meet the criteria listed in the third column. In other words, listed are the NAICS codes into which identified clean economy establishments happen to fall. The industry descriptions are listed in order of relative importance to the segment's level of employment. In general, industries were not listed if they comprised less than five percent of the segment's jobs.

## Table A5. Clean Economy Segments by Industry Description and Major Source of Company Identification

| Clean Economy Segment | Description of Largest NAICS Industries in Segment | Principal Certification/Association Lists | Year List Began |
|---|---|---|---|
| Conservation | Administration of conservation programs; administration of air, water, and solid waste management programs | Industry Codes & D&B Product Info | -- |
| Organic Food and Farming | Grocery wholesalers; other food manufacturing; fruit and vegetable preserving and specialty food manufacturing; dairy manufacturing; bakeries and tortilla manufacturing; animal slaughtering and processing; support activities for crop production; grain and oilseed milling; fruit and nut farming | USDA National Organic Program | 1990 |
| Sustainable Forestry Products | Corrugated and solid fiber box manufacturing; paperboard mills; paper mills; sawmills | Forest Stewardship Council Certification-Recycled<br>SFI Standard<br>Green Spec | 1993<br>1994<br>2004 |
| Regulation and Compliance | Public administration of air, water, and solid waste management programs; administration of conservation programs; executive government offices | Industry Codes & D&B Product Info | -- |
| Training | Vocational rehabilitation services; other specialty trade contractors; civic and social organizations; electronic parts wholesalers | Federal ARRA Green Training Awardees | 2010 |
| Appliances | Household cooking appliance manufacturing; air-conditioning, heating, refrigeration equipment manufacturing; other commercial and service industry manufacturing; other major household appliance manufacturing; vending machine manufacturing; laundry equipment manufacturing. | Energy Star<br>Green Spec | 1992<br>2004 |
| Battery Technologies | Storage battery manufacturing; miscellaneous electrical equipment manufacturing; testing laboratories; motor vehicle suppliers and part wholesalers | Federal ARRA & ARPA-E Awardees<br>Energy Star<br>Venture Capital<br>Federal SBIR Awards<br>*Market Study Information*<br>Industry Codes & D&B Product Info | 2010<br>1992<br>Various<br>Various<br>Various<br>-- |
| Electric Vehicle Technologies | Motor vehicle manufacturing; motor vehicle parts manufacturing; motor vehicle body and trailer manufacturing; electrical equipment manufacturing; other general purpose machinery manufacturing; semiconductor manufacturing | EPA Smart Way<br>Baum & Associates<br>Federal ARRA & ARPA-E Awardees | 2002<br>--<br>2010 |
| Energy-saving Building Materials | Drywall and insulation providers; wood and metal window manufacturing, plastic products manufacturing, prefabricated metal building manufacturing; mineral wool manufacturing; millwork, and lumber wholesalers | Energy Star<br>Cool Roof Rating Council<br>National Association of Energy Service Companies (NAESCO)<br>ARRA Weatherization Assistance Program<br>ARRA Energy Efficiency Block Grants | 1992<br>1998<br>1983<br>2010<br>2010 |
| Energy-saving | Office machinery manufacturing; | Energy Star | 1992 |

| | | | |
|---|---|---|---|
| Consumer Products | semiconductor manufacturing; motor and generator manufacturing; flat glass manufacturing; blind and shade manufacturing; household repair services | Green Spec | 2004 |
| | | Electronic Product Environmental Assessment Tool (EPEAT) | 2007 |
| Fuel Cells | Instrument manufacturing; scientific research and development; miscellaneous electric equipment manufacturing; semiconductor manufacturing; miscellaneous motor vehicle parts manufacturing | United States Fuel Cell Council (USFCC) | 1998 |
| | | National Hydrogen Association (NHA) | 1989 |
| | | Federal ARRA & ARPA-E Awardees | 2010 |
| | | Federal SBIR Awards | Various |
| Green Architecture and Construction Services | Architectural services; engineering services; commercial building construction; plumbing, heating, and air-conditioning contractors. | NAHB Green | 2008 |
| | | Energy Star | 1992 |
| | | ARRA Weatherization Assistance Program | 2010 |
| | | ARRA Energy Efficiency Block Grants | 2010 |
| | | United States Green Building Council (USGBC) | 1993 |
| HVAC and Building Control Systems | Air-conditioning, heating, and commercial refrigeration equipment manufacturing; automatic environmental control manufacturing; plumbing and hvac contractors, non-electric heating equipment manufacturing, engineering services; electric contractors. | Energy Star | 1992 |
| | | Building Performance Institute Gold Star | 1993 |
| | | Mechanical Service Contractors of America (MSCA) Green Star | 2010 |
| Lighting | Electric lighting fixture manufacturing; lamp and part manufacturing; residential lighting fixture manufacturing; other lighting equipment manufacturing; semiconductor manufacturing; electrical equipment wholesalers; sign manufacturing. | Energy Star | 1992 |
| Professional Energy Services | Miscellaneous scientific consulting services; engineering services; management consulting; electric contractors. | Industry Codes & D&B Product Info | -- |
| | | Energy Star | 1992 |
| Public Mass Transit (National Passenger Rail) | School bus transportation; bus and motor vehicle transit systems; mixed mode transit; interurban and rural bus transportation; commuter rail. | Industry Codes & D&B Product Info | -- |
| Smart Grid | Engineering services; instruments manufactured for electricity measurement and testing; electrical contractors; other electronic parts wholesalers; miscellaneous support services; instruments manufactured for measuring, displaying, and controlling industrial processes | Gridwise Alliance | 2003 |
| | | Energy Star | 1992 |
| | | Venture Capital | Various |
| | | Federal SBIR Awards | Various |
| Water Efficient Products | Plumbing fixture fitting manufacturing; bathroom accessories manufacturing; enameled iron and metal sanitary ware manufacturing; plastic plumbing fixture manufacturing; metal valve and pipe fitting manufacturing | WaterSense | 2006 |
| | | Green Spec | 2004 |
| Air and Water Purification Technologies | Miscellaneous industrial machinery manufacturing; other chemical product manufacturing; air purification equipment manufacturing; other commercial and industry machinery manufacturing | Energy Star | 1992 |
| | | "Green Approved" Certification | 2009 |
| | | Greenguard | 2002 |
| | | Green Spec | 2004 |
| | | *Market Study Information* | Various |
| Carbon Storage and Management | Crude petroleum and natural gas extraction; other concrete product manufacturing; engineering services | *Market Study Information* | Various |

| | | | |
|---|---|---|---|
| Green Building Materials | Carpet and rug mills; gypsum product manufacturing; yarn spinning mills; broadwoven fabric mills; wood, window, door manufacturing; paint and coating manufacturing; hardwood or softwood veneer and plywood manufacturing; other millwork; lumber, plywood, and millwork, and wood panel merchant wholesalers. Various other building material manufacturing industries. | Green Spec | 2004 |
| | | Green Seal | 1989 |
| | | NAHB Green Approved | 2009 |
| | | Greenguard | 2002 |
| | | California Gold | 2006 |
| | | Green Label/Green Label Plus | 1992 |
| | | FloorScore | 2005 |
| | | Green Label/Green Label Plus | 1992 |
| | | BioPreferred | 2002 |
| | | Sustainable Attributes Verification and Evaluation (SAVE) | 2008 |
| | | MBDC Cradle-to-Cradle | 2005 |
| | | Indoor Advantage & Indoor Advantage Gold | 2005 |
| | | SMaRT Certification by MTS | 2000 |
| | | United States Green Building Council (USGBC) | 1993 |
| Green Chemical Products | Plastics material and resin manufacturing; paint and coating manufacturing; nitrogenous fertilizer manufacturing; polish and other sanitation good manufacturing; adhesive manufacturing | Green Seal | 1989 |
| | | Green Spec | 2004 |
| | | Greenguard | 2002 |
| | | Design for the Environment (DfE) | 1992 |
| | | MBDC Cradle-to-Cradle | 2005 |
| | | Environmentally Preferred Products | 2008 |
| | | Federal SBIR Awards | Various |
| Green Consumer Products | Non-wood office furniture manufacturing; toilet preparation manufacturing; Wood office furniture manufacturing; urethane and other foam product manufacturing; corrugated and solid fiber box manufacturing; paper mills; fresh and frozen seafood manufacturing; surgical appliance and supplies manufacturing. | Green Seal | 1989 |
| | | Greenguard | 2002 |
| | | Green Spec | 2004 |
| | | Level: Business and Institutional Furniture Manufacturers Association (BIFMA) | 2006 |
| | | BioPreferred | 2002 |
| | | GoodGuide (environmental score of 8 or above) | 2007 |
| | | MBDC Cradle-to-Cradle | 2005 |
| | | Indoor Advantage & Indoor Advantage Gold | 2005 |
| | | UL-Sustainable/Environ./Energy Eff. Product Certification & Verification | 2008 |
| Nuclear Energy | Nuclear electric power generation; research and development. | EIA Information and BLS Employment | 2009 |
| | | *Market Study Information* | Various |
| | | Industry Codes & D&B Product Info | -- |
| | | Venture Capital | Various |
| Pollution Reduction | Analytical laboratory instrument manufacturing; industrial machinery wholesalers; other professional, scientific, and technical services; Air-heating and conditioning equipment wholesalers | Environmental Business Journal | 1988 |
| | | Industry Codes & D&B Product Info | -- |
| Professional Environmental Services | Other scientific and technical consulting services; engineering services; scientific research and development | Environmental Business Journal | 1988 |
| | | Industry Codes & D&B Product Info | -- |

| | | | |
|---|---|---|---|
| Recycled-Content Products Recycling and Reuse | Paper mills; paperboard mills; primary aluminum production; corrugated and solid fiber box manufacturing | Comprehensive Procurement Guidelines (CPG) | 1995 |
| | | Green Spec | 2004 |
| | | Sustainable Attributes Verification and Evaluation (SAVE) | 2008 |
| | | Forest Stewardship Council Certification-Recycled | 1993 |
| | Recyclable material merchant wholesalers; materials recovery facilities | MBDC cradle to cradle | 2005 |
| | | Industry Codes & D&B Product Info | -- |
| Remediation | Remediation services; facilities support services; other specialty trade contractors | Industry Codes & D&B Product Info | -- |
| Waste Management and Treatment | Administration of air and water resource and solid waste management programs; solid waste landfill; other nonhazardous waste treatment and disposal; sewage treatment; solid waste collection | Industry Codes & D&B Product Info | -- |
| | | Venture Capital | Various |
| Biofuels/Biomass | Ethyl alcohol manufacturing; other basic organic chemical manufacturing; wet corn milling; soybean processing; grain and field bean wholesalers; petrochemical manufacturing | BioEnergy Producers Association | 2005 |
| | | Biomass Thermal Energy Council (BTEC) | 2009 |
| | | Renewable Fuels Association (RFA) | 1981 |
| | | EPA AgStar | 1994 |
| | | USDA Rural Energy for America Program (REAP) | 2000 |
| | | Venture Capital | Various |
| | | Federal SBIR Awards | Various |
| Geothermal | Water and sewer line and related structures construction; other electric power generation; air-conditioning and heating equipment and refrigeration equipment manufacturing; electric power distribution; engineering services | Geothermal Energy Association (GEA) | 1972 |
| | | Geothermal Resources Council (GRC) | 1970 |
| | | *Market Study Information* | Various |
| Hydropower | Hydroelectric power generation | EIA Information and BLS Employment | 2009 |
| | | National Hydropower Association (NHA) | 1983 |
| | | *Market Study Information* | Various |
| Renewable Energy Services | Engineering services; scientific research and development; electrical contractors; commercial and institutional building construction; administrative management and general management consulting services; mechanical power transmission equipment manufacturing; custom computer programming services; other electric power generation | Industry Codes & D&B Product Info | -- |
| | | Energy Star | 1992 |
| | | Federal SBIR Awards | Various |
| Solar Photovoltaic | Semiconductor and related device manufacturing; plumbing, heating, and air-conditioning contractors; semiconductor machinery manufacturing | Solar Electric Power Association (SEPA) | 1992 |
| | | Solar Energy Industries Association (SEIA) | 1974 |
| | | American Solar Energy Society (ASES) | 1954 |
| | | *Market Study Information* | Various |
| | | Venture Capital | Various |
| | | Federal SBIR Awards | Various |
| Solar Thermal | Heating equipment manufacturing (except furnaces); other building material dealers; paint and coating manufacturing; aluminum extruded product manufacturing; hvac contractors. | Solar Electric Power Association (SEPA) | 1992 |
| | | Solar Energy Industries Association (SEIA) | 1974 |
| | | American Solar Energy Society (ASES) | 1954 |
| | | Solar Rating and Certification Corp. | 1980 |
| | | Venture Capital | Various |

| | | | |
|---|---|---|---|
| Waste-to-Energy | Other nonhazardous waste treatment and disposal; other electric power generation; materials recovery facilities; hazardous waste treatment and disposal. | BioEnergy Producers Association<br>Venture Capital | 2005<br>Various |
| Wave/Ocean Power | Scientific research and development; engineering services; miscellaneous electrical equipment component manufacturing; electrical apparatus and wiring suppliers wholesalers; electrical contractors | *Market Study Information*<br>*DOE Office of Energy Efficiency and Renewable Energy Wind and Water Program grantees* | Various<br>2008 |
| Wind | Turbine and turbine generator set units manufacturing; electrical contractors; motor and generator manufacturing | American Wind Energy Association (AWEA)<br>Venture Capital<br>*Market Study Information* | 1974<br>Various<br>Various |

**The Strengths and Limitations of Using Dun and Bradstreet and NETS to Determine the Employment Level, Location, and History of Establishments in the Clean Economy**

To identify and locate the specific establishments of clean economy firms in the United States and to tabulate their employment, Battelle used the Dun and Bradstreet company database, which provides the most comprehensive publicly available listing of firms and operations across the nation. Dun and Bradstreet captures its information on companies through updating marketing and credit reports, and makes multiple efforts to contact every establishment in the country. According to literature provided to us by Walls and Associates, D&B launches over 100 million calls per year from four call centers to maintain and update its massive database. Companies have an incentive to report accurately because the information informs their credit scoring and is used by lenders. D&B's sources include the Yellow Pages, credit inquiries, business registrations, payment experiences, public records, court and legal filings, government registries, and news reports. All the information is subject to extensive automated quality checks to look for inconsistencies.

There is good reason to believe that Dun and Bradstreet data accurately measure the level of employment at establishments at any single point in time. Economist David Neumark and colleagues have published an academic article which systematically checks the quality and accuracy of the NETS database, which is developed by Walls and Associates, under license with Dun and Bradstreet. NETS uses Dun and Bradstreet as its underlying source for company information and compiles it into a time series, improving the older records along the way.[40] Neumark and his coauthors examine the accuracy of employment levels, changes, relocations, and coverage of new firms. All of these were found to be highly correlated with public data sources except for short-term (single year) changes in employment. In fact, they generally found NETS/Dun and Bradstreet to have better coverage on small firms than the QCEW from the BLS. For a sample of firms in

[40] David Neumark, Junfu Zhang, and Brandon Wall, "Employment Dynamics and Business Relocation: New Evidence from the National Establishment Time Series." *Research in Labor Economics* (2007): 39-83. Available at http://www.nber.org/papers/w11647.

San Francisco, they found that NETS was actually more accurate than phone book records in terms of capturing newly created establishments.

Similarly, in a methodological paper for the Small Business Administration, the economist Zoltan Acs highlights the advantages of the NETS data in terms of better coverage of the self-employed and less disclosure problems than comparable public data provided by the BLS.[41]

Finally, Brookings and Battelle consulted with labor market information experts who had worked with Dun and Bradstreet or NETS data, and they found them to be the best readily available sources of establishment level jobs information.

Still, despite these strengths, every database has flaws. The Brookings-Battelle team identified quality problems with Dun and Bradstreet establishment records with fewer than five employees for 2010. The smaller records often seemed to refer to the locations of temporary contract work rather than an establishment's headquarters or permanent place of business. For example, independent contractors—doing repair, installation, or cleaning work—who worked for larger firms were often coded as being part of the larger firm. Including them, therefore, would have exaggerated the number of employees counted as part of the clean economy. Likewise, literature on D&B provided to the Brookings-Battelle team from Walls and Associates shows that firms with less than five employees are much less likely to report their job numbers—meaning that the quality of those records is considerably poorer than those of larger establishments.

This concern was so prevalent in establishment records with less than five employees that the Brookings-Battelle team decided to eliminate those records from the database entirely in order to more accurately identify the level and location of employment in the clean economy.[42] While this decision surely eliminated some valid records, the Brookings-Battelle team determined that it was worth the increase in quality. In practice, the elimination of these small records resulted in removing roughly 5 percent of the database's total number of jobs and 50 percent of its establishments, most with zero employees.[43]

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[41] Zoltan Acs, William Parsons, and Spencer Tracy, "High Impact Firms: Gazelles Revisited" (Washington: Small Business Administration, 2008). Available at http://www.insidevtknowledgeworks.com/files/HighImpactFirms2008.pdf

[42] An exception to the rule of including establishments with less than five employees was made for hydropower plants. To generate employment figures for this segment, the Dun and Bradstreet database was not used. Instead, the location of these plants could be verified from the Energy Information Agency (EIA), and employment was estimated for these establishments by sharing out national employment in hydropower to specific plants based on the plant's contribution to electricity production. Electricity production data was obtained from the EIA.

[43] This number was determined prior to the addition of 600,000 more jobs that occurred after revisions to the master list. Therefore the final number of excluded small establishments and jobs therein may have been slightly higher.

To measure the change in employment by establishments of clean economy-producing firms over time, the Brookings-Battelle team used the NETS database. NETS converts the Dun and Bradstreet annual firm data into a time series by compiling the twenty annual snapshots of the full Duns Marketing Information (DMI) file. This file followed over 41.7 million establishments between January 1990 and January 2009. Once the historic data is linked to each firm, Walls and Associates performs a complex series of statistical manipulations to fill in gaps, remove errors, and generally improve the data's accuracy over time. After extensive conversations with industry experts and Walls and Associates, the Brookings-Battelle team decided that this was the most accurate way to get historical information for clean economy establishments in our database.

As with D&B, a note of caution is warranted. There appear to be considerable errors in some of the public sector NETS records for previous years. For example, agencies associated with the U.S. Department of the Interior were recorded as having job gains of 41,035 using NETS data from 2003 to 2009, mostly from the U.S. Fish and Wildlife Service for a total of 71,187 employees. Yet, Brookings researchers found data from the Office of Personnel Management website that shows that the Department of Interior increased employment from 2003 to 2009 by less than 5,000 jobs, from 70,558 to 75,381.[44] While the final level of employment was very close, the change was decidedly not—suggesting large errors in the database's historical records for these agencies.

Brookings researchers discussed this problem with Don Walls of NETS and received an explanation. Since complicated, multi-establishment organizations—especially governments—often change their organization structures by substituting establishments for one another in the National Establishment Time Series (NETS) Database, the methodology used here may occasionally *exaggerate* job changes from 2003 to 2010 because earlier (no longer existing) establishments are not in the Brookings-Battelle Clean Economy Database. Unfortunately, there is no definitive way to know which records show the creation of new offices and employment and which merely reflect changes in organizational reporting.

Fortunately, the historic private sector records (starting in 2003) were found to be more accurate. Using the NETS/D&B database, some of the largest job changes at single private establishments were examined for the 2003 and 2010 period. In cases where public information could be found, the direction of these losses and gain corresponded to local news reports of plant closings, layoffs, or expansions. Moreover, in one case, Brookings researchers interviewed the CEO of a fast growing solar manufacturing firm who confirmed that the rapid job changes in D&B/NETS were almost exactly correct.

Yet, even in the private sector, the size of the changes sometimes appeared to be exaggerated by the NETS/D&B data. For example, two news articles were found on job

[44] U.S. Office of Personnel Management, Table 2 (various years) available at http://www.opm.gov/feddata/html/empt.asp (2011).

changes at establishments of an energy-efficient air-conditioning manufacturing firm. Actual loses in Texas were 653, according to the report, while the NETS/D&B database suggested losses of 1,080. Similarly, a report on an expansion to an existing facility with the same firm at a New York location mentions the hiring of just 25 additional workers, but the NETS/D&B record appears to characterize this expansion as a birth of an entirely new establishment and allocated every employee to it. A similar issue arose with a professional energy services enterprise in Tennessee, where very large job increases were confirmed by local news reports, but appeared to be roughly 50 percent smaller than what the NETS/D&B database reports because the historic NETS/D&B record was too small.

In short, growth figures should be interpreted cautiously—especially in metros and states with a high percentage of jobs in conservation, public mass transit, and regulation. For private sector oriented places, job changes are likely to be more accurate but segment losses are likely to be exaggerated down and segment gains are likely to be exaggerated up.

The reader is invited to review a list of outliers, which has been made available on the Brookings clean economy download page.[45] The segment, metro, state, and change in jobs are reported for all 135 establishments that gained or lost 1000 or more jobs from 2003 to 2010.

**Steps Taken to Ensure and Improve the Reliability and Validity of Method**

Despite the precautions outlined above, there are still many ways to introduce inaccuracies into the database—by misattributing information to specific establishments or from failing to identify the full universe of clean economy establishments.

To guard against misattributing information, the Brookings-Battelle team carefully scrutinized the Dun and Bradstreet records for internal consistency. Such checks included efforts to link the location of establishments to public information from websites; matching the line of business to what is expected from the company's membership affiliation or product type; and ensuring that job numbers for the company were not misallocated exclusively to one establishment, such as the headquarters. Establishment records were not included if Battelle could determine that an error was likely.

To guard against errors associated with omitting clean economy firms or establishments, a number of steps were taken. A preliminary database was shared with research partners with regional expertise in metropolitan areas like Sacramento, Chicago, the counties of the northeast Ohio region, and the states in New England. The research partners were asked to identify mistakes in the database, especially, by their judgment, clean economy firms that were left out of the Brookings-Battelle database.

[45] Brooking-Battelle Clean Economy Database, available at http://www.brookings.edu/metro/clean_jobs.aspx

To give an example of how this worked, the Brookings-Battelle partners in Sacramento identified establishments that were not found in the Brookings-Battelle database. Of that group, most were not included because they were too small to meet the quality control standard (i.e. they had fewer than five employees). Another group of establishments were simply not in the Dun and Bradstreet database, perhaps because they were recent start-ups, and a final group did not show up on any list used by Brookings-Battelle researchers.

Informed by these reports, a systematic effort was made by the Brookings-Battelle team to figure out why certain clean firms were not identified. From this effort, a number of new lists were added to the list of lists, including federal sub-contractors that conducted work funded by Energy Efficiency and Conservation Block Grants and the Weatherization Assistance Program. Grantees were added from programs run out of the Department of Energy's Office of Energy Efficiency and Renewable Energy and ARPA-E program. Companies with gold certifications from the Building Performance Institute and companies with Green Star Certification from Mechanical Service Contractors of America were also added during this stage.

A final quality check was conducted using the finished database. Some reviewers of this project at an early stage expressed concern that the method might miss start-up companies that were formed within the last couple of years and were therefore less likely to be on lists or to be covered in the Dun and Bradstreet database. To assess this and the general validity of the method, the Brookings-Battelle team examined a list of *The Guardian* newspaper's Global Cleantech 100. These 100 highly-rated companies were selected by a panel of 60 experts from around the world under the criteria that the companies represent the highest potential for market impact, are for-profit and private, and are not listed on any major stock exchange.[46] Of these, 58 had establishments in the United States and 47 were captured by the Brookings-Battelle team's method. Of those not captured, six companies were not carried by Dun and Bradstreet (perhaps because they were too new) and four had fewer than five employees (as listed by Dun and Bradstreet) and so were not included for the reasons mentioned above. One company was simply not on any of the lists used to find clean firms. To summarize, 81 percent (or 47 out of 58) of these new clean tech startups were included in the Brookings-Battelle.

In other words, through comparisons with other national studies and refined lists like Global Cleantech100, there is evidence that the Brookings-Battelle method offers a reasonably accurate measure of the clean economy. Moreover, the from-the-ground-up method makes this the most comprehensive study to date. No other dataset provides such fine-grained classification and no other dataset provides national, state, metropolitan, and county data across the entire United States. The forthcoming BLS green jobs study will provide some of these geographic advantages, but will not be able to disclose job numbers in many locations because of survey-participation nondisclosure agreements.

[46] "Global Cleantech 100," *The Guardian*, available at http://www.guardian.co.uk/globalcleantech100/cleantech-100-2010-list?CMP=twt_gu (January 2011).

## How Further Measures Were Calculated

Beyond clean energy establishment and jobs figures, this report provides information of several other types that were developed in different ways. In general these approaches used the segment, NAICS code, and employment data developed in the Brookings-Battelle Clean Economy Database to connect with and provide estimates from other data sources and types. The sections below describe the methods used.

*Growth Rates*

Because of the way the data was constructed, there was no information in this database on firm closings. True net growth consists of four factors, two on the positive side of the ledger and two on the negative side. On the positive side, there are job gains from openings of new establishments and expansions of existing establishments. On the negative side, there are job losses from closings and contractions. This database lacks closings but has access to this jobs history of establishments currently in business. This means that all growth rates overstate true growth by leaving out one of the negatives. This is not a problem when comparing growth rates in the clean economy internally (that is from segment to segment or metro to metro). However, when comparing to U.S. growth rates, adjustments need to be made. To adjust U.S. growth for the loss of jobs from closing establishments, information was obtained from two sources. The first was NETS; Walls and Associates generated a national figure based on job histories of establishments in business in 2009. Unfortunately, due to time lags in compiling the NETS data, this only yielded growth rates from 2003 to 2008. To get 2003 to 2010 figures, data was taken from the Bureau of Labor Statistics' Business Employment Dynamics series.[47] This unique dataset contains national and industry-level data on the four factors of growth for almost every establishment in the private sector.

The challenge in adjusting growth numbers in this fashion lies not with the end year (2010), in which all jobs records are known. Rather the challenge lies in finding the proper base year jobs number that adjusts for losses from closings during the intervening years. To calculate a growth rate that excludes jobs losses from closing establishments over a period (e.g. 2003 to 2010), job losses from "deaths" in all subsequent years were subtracted from the total number of jobs for the base year. For example, consider a hypothetical set of numbers in which the total number of jobs in 2003 is 100 million, and the total number of jobs in 2010 is 200 million. If we know that 25 million jobs were lost from establishment deaths between 2003 and 2010, then 75 million should be used as the new base year to calculate growth of non-closing establishments. In this example, the growth rate increases from 100 percent—the true growth rate—to 167 percent, when job losses from establishment deaths are excluded.

[47] BLS Business Employment Dynamics, available at http://www.bls.gov/bdm/home.htm (2011).

The growth rates reported in this report are annualized using a standard discreet annual compounding formula. That would turn the hypothetical 167 percent growth figure into 15 percent on an annual basis.

*Age of Segments*

Year of establishment birth was provided by Dun and Bradstreet for 79.6 percent of the establishments in the Brookings-Battelle database. Those with missing values were assumed to have been created before D&B began their work in 1989 or to be new, as it takes D&B a few years sometimes to obtain start-year information from their surveys. For the four segments with less than 50 percent coverage (i.e. nuclear, hydropower, public mass transit, and air and water purification, all of which have many very old establishments), missing values were treated as missing. Caution should be used in interpreting the start years for these segments, which, in all likelihood, are older than reported. For segments with better year-start coverage, missing values for year-start were replaced with the first year that the establishment went from having zero jobs to some positive number of jobs. This strategy of replacing the start year with the first year of employment was recommended by Walls and Associates, the proprietor of the NETS.

*Clustered vs. Isolated*

To facilitate economic development analysis and highlight industry clusters, this report distinguishes between clustered establishments and isolated establishments. In general, this is a continuous and not dichotomous variable: Establishments are more clustered if they are surrounded by more workers in other establishments or surrounded by a larger number of other establishments.[48] Both definitions were used in regression analyses that established a strong statistical relationship between the log of clustering in 2003 and the log of subsequent clean economy employment growth through 2010. The use of a log-log model corresponds to growth. The results of this analysis are presented in Table A6.

The model controls for other relevant characteristics of establishments that may be correlated with clean economy job growth, such as the establishment's number of jobs in 2003, the total number of jobs in the county (including those outside the clean economy), the number of jobs in the segment nationally, the age of the establishment, the number of clean economy jobs and physical locations (i.e., establishments) in the establishment's company, and whether or not the establishment is a headquarters, a branch, or a standalone (omitted below) office. Column one adjusts for whether or not the establishment is in the public sector. Column two includes binary variables representing every 3-digit NAICS industry. This adjusts for the unmeasured differences of being in a different industry. Column three adjusts for the effects of being in a different state and a

[48] J. Vernon Henderson, "Marshall's Scale Economies." *Journal of Urban Economics* 53 (2003): 1-28; Gilles Duranton, Philippe Martin, Thierry Mayer, and Florian Mayneris, *The Economics of Clusters: Evidence from France* (Forthcoming Oxford University Press: 2010). Stuart Rosenthal and William Strange, "Evidence on the Nature and Sources of Agglomeration Economies." In J.V. Henderson and J. F. Thisse, ed., *Handbook of Regional and Urban Economics*, vol. 4 (Amsterdam: North-Holland, 2004).

different industry.

Finally, column four uses a different definition of clustering based on the number establishments instead of the number of jobs.

These variations to the model and others not shown all show the same result: clustered establishments grew roughly 2.1 to 3.2 percent (two raised to the power of the coefficient shown below) higher for every doubling in cluster size (i.e. doubling in the number of jobs in other establishments in the county for the first definition, or a doubling in the number of other establishments). In other words, clustered establishments grew significantly faster from 2003 to 2010 relative to isolated establishments, and growth was faster as the cluster increased in size. As for other results, being a headquarters or branch of a company resulted in better growth than being a standalone establishment; younger establishments grew faster; and county employment size made no difference, suggesting that clustering can boost growth even in small counties.

**Table A6. Results of Regressing 2003 Establishment Clustering on 2010 Employment Levels**

| | Log of Jobs in 2010 | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Log of Jobs in 2003 | 0.674*** | 0.671*** | 0.671*** |
| | (0.00894) | (0.00912) | (0.00915) |
| Log of County Employment at Other Establishments in Same Segment, 2003 | 0.0334*** | 0.0306*** | 0.0306*** |
| | (0.00404) | (0.00417) | (0.00410) |
| Log of County Employment, 2003 | 0.00157 | 0.00659 | 0.00787* |
| | (0.00433) | (0.00456) | (0.00478) |
| Number of U.S. Jobs in Segment, 2003 | -3.52e-07*** | -2.58e-07*** | -2.54e-07*** |
| | (5.02e-08) | (6.77e-08) | (6.80e-08) |
| Age of Establishment | -0.00153*** | -0.00249*** | -0.00231*** |
| | (0.000394) | (0.000463) | (0.000471) |
| Number of Jobs in Company, 2003 | 0.0228** | 0.00753 | 0.00695 |
| | (0.0100) | (0.0101) | (0.0101) |
| Number of Establishments in Company, 2003 | -0.0144 | 0.00116 | 0.000784 |
| | (0.0108) | (0.0108) | (0.0108) |
| Branch of Company | 0.0266** | 0.0247* | 0.0243* |
| | (0.0129) | (0.0130) | (0.0132) |
| Headquarters of Company | 0.204*** | 0.200*** | 0.199*** |

| | | | |
|---|---|---|---|
| | (0.0132) | (0.0132) | (0.0133) |
| In public sector | 0.00897 | | |
| | (0.0154) | | |
| Constant | 0.910*** | 0.956*** | 1.691*** |
| | (0.0221) | (0.0233) | (0.0459) |
| Fixed Effects | None | NAICS-3 | NAICS-3 & state |
| Observations | 30,600 | 30,600 | 30,600 |
| Adjusted R-squared | 0.657 | 0.662 | 0.662 |

Robust standard errors in parentheses, clustered on counties. *** p<0.01, ** p<0.05, * p<0.1. A few robustness checks were implemented. Similar results were obtained using MSA instead of counties at the relevant cluster boundary, but that reduced the sample size to MSAs—a loss of approximately 3000 observations and weakened the effects somewhat. Using the county-based definition, strong results were obtained using the number of establishments instead of the number of jobs to measure clusters, but the jobs-based definition predicted growth better when aggregated to a binary definition—see below. Finally, a model in which segment effects are added produces results similar to those in column one.

For the purposes of statistical reporting, however, a dichotomous cutoff was needed. To be clustered, by this measure, establishments had to be located in a county in which other establishments in the same segment had a significant presence. To determine what threshold mattered, a few definitions were used. The strongest results were obtained by implementing a criterion that required exposure to one percent of the national market in that segment, measured by jobs in the same county. Under this definition, to be clustered, an establishment had to be in the same county and segment as at least 1.0 percent of all other U.S. jobs in that clean economy segment. This means that a very large single establishment does not make a cluster even if it represents disproportionate employment in a county. Likewise, a few very small establishments do not make a cluster unless they are in a segment with a very small number of jobs (like ocean/wave power). Using this definition, establishments that were clustered in 2003 grew by 4.3 percent each year from 2003 to 2010, while isolated establishments grew by only 3.2 percent. Other definitions based on the presence of jobs in the same segment yielded similar but less pronounced results in favor of clusters.

Table A7 shows how growth differed between clustered and non-clustered establishments using different definitions, including an employment cutoff of 1.0, 0.1, or 0.01 percents, and a location quotient greater than or equal to one. Here a cutoff of 1.0 percent means that the total number of jobs in other establishments must equal at least one percent of U.S. employment for the establishments to be considered clustered. Another measure, the location quotient, has a numerator equal to the ratio of jobs in other establishments of the same segment and county in 2003 to total county employment in 2003. The denominator is the ratio of total U.S. jobs in the segment in 2003 to total U.S. employment in 2003. It gives greater weight to smaller counties that have a disproportionate number of jobs in the same segment—even if the segment is small overall. Finally, though not shown in the table, the authors also tried calculating the one percent cluster cutoff based on jobs in other companies—not just other physical establishments. This could be important since some companies have multiple establishments at one location (if the activities differ

significantly). This produced almost identical results to what is shown in column one of the table below.

**Table A7. Annual Job Growth Rates from 2003-2010 for Various Definitions of Isolated and Clustered Establishments in the Clean Economy**

| | 1% Segment Job Share | 0.1% Segment Job Share | 0.01% Segment Job Share | LQ>1 |
|---|---|---|---|---|
| **All Clean Economy Establishments** | | | | |
| Clustered | 4.6% | 3.9% | 3.9% | 3.9% |
| Isolated | 3.2% | 2.9% | 2.3% | 3.1% |
| Percent of establishments meeting criteria | 10.8% | 48.3% | 74.7% | 42.4% |
| **Establishments in Export-oriented Segments** | | | | |
| Clustered | 3.0% | 2.9% | 3.0% | 2.6% |
| Isolated | 2.4% | 2.1% | 1.7% | 2.4% |
| Percent of establishments meeting criteria | 14.2% | 51.4% | 71.2% | 37.6% |

The analysis above calculated clustering for every segment in the clean economy. Yet, the theoretical benefits of clustering are arguably more important in private sector and export-oriented industries (or segments), where competition plays a larger role than in the public sector, and segments like public transit, waste management, and hydropower.[49] For that reason, the main report and findings report state and metropolitan area clustering for segments that are export-oriented. Specially, establishments in segments that export less than $4,000 per job were excluded (see Table A9 below for these nine segments). The bottom half of Table A7 reports the growth rate differences for clustered versus isolated establishments for the 30 export-oriented segments. The advantage of clustering is roughly the same in relative terms, but the growth rates of these establishments are depressed for both the clustered and isolated group. The "non-tradable" segments grew faster (see cautionary note, however, on accuracy of public-sector growth data), but both benefitted from being clustered.

As in the analysis using all data, the 1.0 percent cutoff analysis was replicated by re-defining clusters based on the presence of jobs in other *companies*. The results strongly favored clusters (3.4 versus 2.3 percent growth). The results were also replicated defining proximity at the metropolitan rather than county-level scale. The results were similar for the 0.1 percent cutoff, but less pronounced in favor of clusters—though clusters still grew faster.

[49] Still, even these segments, could be more efficient or productive if they have access to larger pools of labor—which facilitates matching—relevant infrastructure—which facilitates sharing—and educational networks.

*Employment and other comparisons*

Fossil fuel employment for the national economy was calculated primarily by using national data from U.S. Census Bureau's County Business Patterns. For this measure, all jobs were included that existed in the following NAICS codes listed in Table A8. However, some jobs involved in the extraction of fossil fuels and geological mining and engineering are employed in establishments with different industry NAICS. To capture these jobs, data from the Occupational Employment Statistics program was used to determine the percentage of jobs in various industries that were dedicated to extraction and geological work that is relevant to fossil fuels. This percentage was then multiplied by total employment for those industries to estimate the number of jobs outside of entirely fossil fuel industries that work primarily in the fossil fuel economy.

The list of NAICS was informed by a 2009 study of the oil and gas industry done by PricewaterhouseCoopers for the American Petroleum Institute. The list used here is more inclusive, largely because every industry in NAICS 324, which includes coal, was used. That study arrived at a direct employment figure of 2.1 million using 2007 data.[50] The estimates reported here range from 1.3 million, if distribution, transportation, and wholesalers are excluded, to 2.4 million if they are included. Those activities were not included in the analysis of the clean economy, and so 1.3 million is the most accurate comparison.

Employment totals for the technology and healthcare sectors were obtained directly from Moody's Economy.com, which lists four-digit NAICS that are part of the IT-producing sector as part of its "special aggregates." Employment from the biotech sector was quoted from a Battelle industry report similar to this one.[51]

**Table A8. Industries Included in Analysis of Fossil Fuel Sector by Employment**

| Industry Name | NAICS | Number of 2009 Jobs |
|---|---|---|
| **Fossil Fuel Production Economy** | | |
| Mining, Quarrying, and Oil and Gas Extraction | 21 | 641,856 |
| Petroleum and Coal Products Manufacturing | 324 | 114,515 |
| Oil and Gas Pipeline and Related Structures Construction | 23712 | 98,671 |
| Petrochemical Manufacturing | 32511 | 25,736 |

[50] American Petroleum Institute, "The Economic Impacts of the Oil and Natural Gas Industry on the U.S. Economy: Employment, Labor Income and Value Added" (2009). This study also found that an additional 5 million jobs in the oil and gas industry are induced or indirectly created by spending from the oil and gas industry and its employees. This method, however, ignores that jobs created in the oil and gas industry are also the result of spending in other industries, and in the absence of an exogenous short-term source of spending by the industry, the measures of indirect or induced jobs is a meaningless figure and one suspects it is used to inflate the importance of the industry for political purposes.

[51] Battelle and Biotechnology Industry Organization, "State Bioscience Initiatives 2010" (2010).

| | | |
|---|---|---|
| Mining and Oil and Gas Field Machinery Manufacturing | 33313 | 71,059 |
| Motor Vehicle Gasoline Engine and Engine Parts Manufacturing | 33631 | 45,958 |
| Fossil Fuel Electric Power Generation | 221112 | 153,268 |
| All Other Industrial Machinery Manufacturing | 333298 | 3,942 |
| Occupations in Extraction; Geological Mining and Engineering | Shares of 53, 54, 55, 56, 238 | 17,784 |
| **Fossil Fuel Distribution, Transportation, and Wholesalers** | | |
| Gasoline Stations | 447 | 824,382 |
| Pipeline Transportation | 486 | 42,287 |
| Natural Gas Distribution | 2212 | 116,781 |
| Petroleum and Petroleum Products Merchant Wholesalers | 4247 | 96,811 |
| Construction and Mining (except Oil Well) Machinery and Equipment Merchant Wholesalers | 42381 | 79,113 |
| Fuel Dealers | 45431 | 81,754 |

*Exports, Occupations, and Wage*

The main assumption that supports estimates of exports, occupations, and wages in this report is that clean economy establishments are similar to non-clean economy establishments in the same industry. This assumption could not be tested using the data produced for this report. However, an analysis of 1992 and 2002 data from economists Randy Becker and Ronald Shadbegian provides evidence that it is a reasonable assumption. They found that there was no difference in compensation, employment patterns, and exporting between manufacturers of environmental products and manufacturers of non-environmental products, when controlling only for industry (4 digit SIC).[52] A few significant differences emerged after controlling for a variety of other factors, but overall environmental products manufacturers were found to be very similar to other manufacturers in the same industry.

*Exports*

Exports were estimated based on the industry code of the clean economy establishments, as identified by Dun and Bradstreet. Each establishment's NAICS code was used to identify its export industry. For goods, this was a three digit NAICS category that was then matched to U.S. export data from the U.S. International Trade Commission website; for services, a cross-walk between NAICS and Bureau of Economic Analysis service export categories was used at the three and four digit level to identify the establishment's service export industry. Then the ratio of clean economy establishment jobs to all U.S. industry jobs was calculated for the establishment's export industry, and this ratio was multiplied by the value of 2009 U.S. exports for that industry. In other words, U.S

[52] Becker and Shadbegian, "Environmental Products Manufacturing:."

exports in a given industry were allocated to establishments based on the establishment's share of employment in that industry. From the establishment level, exports and exports per job could be calculated by various categories, segments, and geographic areas.

This approach was applied to metropolitan areas in recent Brookings research and is described in detail in that report.[53] That report describes how exports of travel and tourist services and royalties by industry were calculated using data from the BEA and the IRS respectively.

The value of national exports per job was calculated using employment data from Moody's Economy.com. Re-exports of goods—those goods brought in to the United States temporarily without value added—were excluded from the analysis.

**Table A9. Estimated Export Orientation of Clean Economy Segments**

| Clean Economy Segment | Exports per Segment, million 2009 dollars | Segment Exports per Job, 2009 dollars |
|---|---|---|
| Biofuels/Biomass | $3,910.3 | $189,088 |
| Green Chemical Products | $4,046.2 | $178,861 |
| Electric Vehicle Technologies | $1,961.1 | $124,825 |
| Wind | $2,846.4 | $117,164 |
| Battery Technologies | $1,322.0 | $81,885 |
| Solar Photovoltaic | $1,943.4 | $80,464 |
| Fuel Cells | $526.5 | $74,701 |
| Air and Water Purification Technologies | $1,574.7 | $63,037 |
| Recycled-Content Products | $3,740.2 | $62,638 |
| Water Efficient Products | $751.1 | $57,487 |
| Appliances | $2,080.7 | $56,838 |
| Energy-saving Consumer Products | $1,081.6 | $56,127 |
| Green Consumer Products | $3,724.5 | $48,205 |
| Lighting | $685.2 | $47,922 |
| HVAC and Building Control Systems | $3,442.7 | $46,776 |
| Sustainable Forestry Products | $2,695.3 | $44,146 |
| Solar Thermal | $198.0 | $36,801 |
| Smart Grid | $561.3 | $35,108 |
| Green Building Materials | $2,505.1 | $32,714 |
| Professional Energy Services | $1,507.9 | $30,206 |
| Organic Food and Farming | $3,856.7 | $29,677 |
| Pollution Reduction | $275.5 | $27,496 |
| Clean Coal and Carbon Sequestration | $10.0 | $25,678 |

[53]Istrate, Rothwell, and Katz, "Export Nation."

| | | |
|---|---|---|
| Energy-saving Building Materials | $3,365.6 | $20,788 |
| Renewable Energy Services | $35.0 | $17,650 |
| Professional Environmental Services | $2,272.1 | $16,101 |
| Wave/Ocean Power | $4.2 | $11,291 |
| Nuclear Energy | $802.3 | $10,733 |
| Geothermal | $22.1 | $8,131 |
| Green Architecture and Construction Services | $275.8 | $4,908 |
| Waste Management and Treatment | $1,323.7 | $3,428 |
| Recycling and Reuse | $233.3 | $1,805 |
| Remediation | $74.0 | $1,316 |
| Training | $0.2 | $798 |
| Waste-to-Energy | $1.7 | $513 |
| Conservation | $146.8 | $466 |
| Hydropower | $16.6 | $300 |
| Regulation and Compliance | $32.9 | $232 |
| Public Mass Transit | $18.6 | $53 |

*Occupations*

Occupational information was estimated based on the industry codes of the establishments in the Brookings-Battelle clean economy database. The U.S. BLS's Occupational Employment Statistics (OES) program provides estimates of occupations for most four-digit NAICS.[54] These measures were used to link occupational profiles to the NAICS employment information provided by Dun and Bradstreet and NETS in the clean economy database. The estimated percent of industry employment in the given occupation (given by OES) was multiplied by the number of jobs in that establishment to calculate the occupational profiles for each establishment. These minor occupations were then regrouped into major occupational categories using the OES-provided Standard Occupational Classifications (SOC). The major groupings were then ranked by median national wage. Those in the middle of the distribution and particularly likely to be part of the clean economy were deemed "green collar" by Brookings. Table A10 shows every major occupation, as determined by BLS, sorted by wage, along with educational attainment information, which was estimated using data from the Employment Projections Program.[55] It is clear that those deemed green collar are in the middle of the wage distribution and tend to be over-represented in the clean economy.

To readers seeking to replicate this exercise, more details are required. The BLS does not have the same level of detailed occupational coverage of the public sector and the agricultural sector, which correspond to NAICS 92 and 11, as it does of other industries. Instead, the BLS provides occupational information for agricultural workers in NAICS

[54] Occupational Employment Statistics, available at http://www.bls.gov/oes/oes_dl.htm#2009 (2011).
[55] Employment Projections Program, available at http://www.bls.gov/emp/ep_table_111.htm#1 (2011).

115 and information for public sector workers based on whether or not the worker is a local, state, or federal government employee. Because almost 30 percent of all clean economy jobs in are in these two sectors (agriculture and public administration), the BLS data was supplemented with data from the 2009 American Community Survey (ACS).

The ACS has information on industry and occupation for almost every respondent in the labor force. 2009 individual data for one percent of the entire U.S population was accessed using the Integrated Public Use Microdata Series (known as IPUMS).[56] The share of workers with occupations in each industry was calculated, and this information was added to the BLS data for the public sector and all agricultural, fishing, hunting, and forestry sectors, where the information was missing from BLS. Specifically, the following three-digit NAICS utilized the ACS data: 111, 112, 113, 114 (Agriculture industries), and 921, 922, 923, 928 (the public sector). For public sector industries not included in the ACS (i.e. those not listed in the previous sentence), the BLS public sector occupational information was linked to establishments based on whether or not the establishment was in local, state, or federal government. To make that identification, company names were classified accordingly.

This process ultimately led to 96.6 percent coverage for occupations, with no establishment having less than 73 percent of its jobs coded to occupations. The coverage was not as complete for the education-to-jobs data, because the educational attainment estimates are not reported by BLS for every SOC code. Still, 96.1 percent of all jobs in the clean economy database were classified according to education attainment using this method.

**Table A10. Wage and Education Characteristics of Major Occupations in the Clean Economy**

| Occupational Title | Median Annual Wage, 2009 dollars | Share of Workers in Occupation with High School Diploma or Less | Share of all Clean Economy Occupations by Percentage | Share of all U.S. Occupations by Percentage |
|---|---|---|---|---|
| **High Wage/High Skilled Occupations** | | | | |
| Management | $89,330 | 16.8% | 5.7% | 4.7% |
| Legal | $74,030 | 7.2% | 0.7% | 0.8% |

[56] Steven Ruggles, J. Trent Alexander, Katie Genadek, Ronald Goeken, Matthew B. Schroeder, and Matthew Sobek. "Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]" (Minneapolis: University of Minnesota, 2010).

| | | | | |
|---|---|---|---|---|
| Computer & math | $72,900 | 7.0% | 2.1% | 2.5% |
| Architecture & engineering | $68,790 | 10.8% | 5.7% | 1.8% |
| Business & financial | $58,910 | 13.9% | 5.8% | 4.6% |
| Life, physical, & social science | $58,300 | 7.7% | 2.3% | 1.0% |
| Healthcare practitioner & technical | $57,690 | 9.9% | 1.2% | 5.5% |
| Education, training, & library | $45,210 | 11.3% | 0.4% | 6.5% |
| Arts, design, entertainment, sports, & media | $42,450 | 13.4% | 0.6% | 1.3% |
| **Category Totals** | **$63,068** | **11.0%** | **24.4%** | **28.8%** |
| **Moderate Wage/Moderate Skill Green Collar** | | | | |
| Installation, maintenance, and repair occupations | $39,600 | 55.4% | 6.2% | 3.9% |
| Community and social services occupations | $38,970 | 11.2% | 1.4% | 1.4% |
| Construction and extraction occupations | $38,770 | 69.1% | 7.2% | 4.4% |
| Protective service occupations | $36,170 | 33.3% | 4.5% | 2.4% |
| Office and administrative support occupations | $30,410 | 39.5% | 14.1% | 17.1% |
| Production occupations | $29,970 | 67.8% | 15.9% | 6.8% |
| Transportation and material moving occupations | $28,010 | 68.4% | 19.3% | 6.8% |
| **Category Totals** | **$34,557** | **51.8%** | **68.7%** | **42.9%** |
| **Low Wage/Low Skill Occupations** | | | | |
| Healthcare support occupations | $24,720 | 47.3% | 0.3% | 3.0% |
| Sales and related occupations | $23,940 | 40.5% | 3.4% | 10.5% |
| Building and grounds cleaning and maintenance occupations | $22,350 | 74.2% | 0.9% | 3.3% |
| Personal care and service occupations | $20,770 | 45.8% | 1.2% | 2.6% |
| Farming, fishing, and forestry occupations | $19,610 | 75.0% | 0.7% | 0.3% |
| Food preparation and serving related occupations | $18,490 | 66.3% | 0.4% | 8.6% |
| **Category totals** | **$21,647** | **53.8%** | **6.9%** | **28.3%** |

Notes: Brookings analysis of the Brookings-Battelle Clean Economy Database and industry-occupation estimates from the U.S. Bureau of Labor Statistics' Occupational Employment Statistics (OES) and Employment Projections programs. Occupations were estimated based on 4-digit NAICS codes. Missing data (for the public sector and agricultural workers) was supplemented using the 2009 American Community Survey--accessed through Integrated Public Use Microdata Series (IPUMS) Version 4.0. The rows with category totals display the sum of the percentages and the average of the median wages and educational requirements.

*Wages*

The Dun and Bradstreet/NETS data does not provide information regarding wage levels for company records. Wages by occupation are provided by the Bureau of Labor Statistics' OES program for the United States and metropolitan areas. To determine a national clean economy wage, the analysis calculated a weighted average of the median wage for all minor occupations in the clean economy. The occupations were obtained using the method outlined above.

These BLS-identified minor occupations were aggregated to a shorter list of BLS-identified major occupations to generate the national occupational findings discussed

above. Based on the national median wages of each of these major occupations, a clean economy wage was estimated for each segment and category using a weighted average of the median wages (with jobs as the weight).

To estimate clean economy wages at the metropolitan (and state) level, a weighted average of the median metropolitan (or state) wage for each major occupation was calculated for every metropolitan area (and state) based on the major occupations identified using the method described above.

In essence, the wage method used the NAICS codes reported by Dun and Bradstreet/NETS to first identify the major occupations at each establishment, and then assumed that clean economy workers at those occupations earned the median metropolitan (or state) wage for that same occupation. The major occupations are listed in Table A10.