Sizing the Green Economy:

A National and Regional Green Jobs Assessment

SIZING THE CLEAN ECONOMY

A NATIONAL AND REGIONAL GREEN JOBS ASSESSMENT

Metropolitan Policy Program
at BROOKINGS

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A NATIONAL AND REGIONAL GREEN JOBS ASSESSMENT

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EXECUTIVE SUMMARY

The "green" or "clean" or low-carbon economy—defined as the sector of the economy that produces goods and services with an environmental benefit—remains at once a compelling aspiration and an enigma.

As a matter of aspiration, no swath of the economy has been more widely celebrated as a source of economic renewal and potential job creation.

Again this year President Obama spoke in his State of the Union Address of "the promise of renewable energy" and environmental pursuits that will "strengthen our security, protect our planet, and create countless new jobs for our people." Since then, a global "race to clean" has gained new urgency with numerous nations—such as China, Japan, and the United Kingdom—all having made new commitments to invest in the low-carbon and environmental goods sector as a source of quality jobs, exports, and industry growth.

Yet, the clean economy remains an enigma: hard to assess. Not only do "green" or "clean" activities and jobs related to environmental aims pervade all sectors of the U.S. economy; they also remain tricky to define and isolate—and count.

The clean economy has remained elusive in part because, in the absence of standard definitions and data, strikingly little is known about its nature, size, and growth at the critical regional level.

Currently no comprehensive national database exists on the spatial geography of the clean economy and its sub-industries, although important work has assessed the clean economy across states. And while numerous studies have analyzed individual regional clean or green industries, a proliferation of definitions and the absence of data for large numbers of regions has made it difficult to situate regional clean economies in a national and comparative context.

The result: Debates about the so-called "green" economy and "green jobs" have frequently been short on facts and long on speculation, assertion, and partisanship.

Which gets to the impetus of this report: Seeking to address some of these problems, the Metropolitan Policy Program at Brookings worked with Battelle's Technology Partnership Practice to develop, analyze, and comment on a detailed database of establishment-level employment statistics pertaining to a sensibly defined assemblage of clean economy industries in the United States and its metropolitan areas.

Covering the years 2003 to 2010 for every county in the United States, the resulting information (available for download at http://www.brookings.edu/metro/clean_economy.aspx) and this report represent the first study of the U.S. clean economy to provide timely information that is both comprehensive enough in its scope and detailed enough in its categorization to inform national, state, and regional leaders on the dynamics of the U.S. low-carbon and environmental goods and services "super-sector" as they are transpiring in regions and metropolitan areas. This information is then employed in a discussion of how the nation, the states, and localities and regions might address a number of key policy problems that may be slowing the growth of the clean economy.

Most importantly, "Sizing the Clean Economy: A National and Regional Green Jobs Assessment" concludes that:

- **The clean economy, which employs some 2.7 million workers, encompasses a significant number of jobs in establishments spread across a diverse group of industries.** Though modest in size, the clean economy employs more workers than the fossil fuel industry and bulks larger than bioscience but remains smaller than the IT-producing sectors. Most clean economy jobs reside in mature segments that cover a wide swath of activities including manufacturing and the provision of public services such as wastewater and mass transit. A smaller portion of the clean economy encompasses newer segments that respond to energy-related challenges. These include the solar photovoltaic (PV), wind, fuel cell, smart grid, biofuel, and battery industries

- **The clean economy grew more slowly in aggregate than the national economy between 2003 and 2010, but newer "cleantech" segments produced explosive job gains and the clean economy outperformed the nation during the recession.** Overall, today's clean economy establishments added half a million jobs between 2003 and 2010, expanding at an annual rate of 3.4 percent. This performance lagged the growth in the national economy, which grew by 4.2 percent annually over the period (if job losses from establishment closings are omitted to make the data comparable). However, this measured growth heavily reflected the fact that many longer-standing companies in the clean economy—especially those involved in housing- and building-related segments—laid off large numbers of workers during the real estate crash of 2007 and 2008, while sectors unrelated to the clean economy (mainly health care) created many more new jobs nationally. At the same time, newer clean economy establishments—especially those in young energy-related segments such as wind energy, solar PV, and smart grid—added jobs at a torrid pace, albeit from small bases

- **The clean economy is manufacturing and export intensive.** Roughly 26 percent of all clean economy jobs lie in manufacturing establishments, compared to just 9 percent in the broader economy. On a per job basis, establishments in the clean economy export roughly twice the value of a typical U.S. job ($20,000 versus $10,000). The electric vehicles (EV), green chemical products, and lighting segments are all especially manufacturing intensive while the biofuels, green chemicals, and EV industries are highly export intensive

- **The clean economy offers more opportunities and better pay for low- and middle-skilled workers than the national economy as a whole.** Median wages in the clean economy—meaning those in the middle of the distribution—are 13 percent higher than median U.S. wages. Yet a disproportionate percentage of jobs in the clean economy are staffed by workers with relatively little formal education in moderately well-paying "green collar" occupations

- **Among regions, the South has the largest number of clean economy jobs though the West has the largest share relative to its population.** Seven of the 21 states with at least 50,000 clean economy jobs are in the South. Among states, California has the highest number of clean jobs but Alaska and Oregon have the most per worker

- **Most of the country's clean economy jobs and recent growth concentrate within the largest metropolitan areas.** Some 64 percent of all current clean economy jobs and 75 percent of its newer jobs created from 2003 to 2010 congregate in the nation's 100 largest metro areas

- **The clean economy permeates all of the nation's metropolitan areas, but it manifests itself in varied configurations.** Metropolitan area clean economies can be categorized into four-types: service-oriented, manufacturing, public sector, and balanced. New York, through mass transit, embodies a service orientation; so does San Francisco through professional services and Las Vegas through architectural services. Many Midwestern and Southern metros like Louisville; Cleveland; Greenville, SC; and Little Rock—but also San Jose in the West—host clean economies that are heavily manufacturing oriented. State capitals are among those with a disproportionate share of clean jobs in the public sector (e.g. Harrisburg, Sacramento, Raleigh, and Springfield). Finally, some metros—such as Atlanta; Salt Lake City; Portland, OR; and Los Angeles—balance multi-dimensional clean economies

- **Strong industry clusters boost metros' growth performance in the clean economy.** Clustering entails proximity to businesses in similar or related industries. Establishments located in counties containing a significant number of jobs from other establishments in the same segment grew much faster than more isolated establishments from 2003 to 2010. Overall, clustered establishments grew at a rate that was 1.4 percentage points faster each year than non-clustered (more isolated) establishments. Examples include professional environmental services in Houston, solar photovoltaic in Los Angeles, fuel cells in Boston, and wind in Chicago

The clean economy **permeates all of the nation's metropolitan areas**, but it manifests itself in varied configurations.

The measurements and trends presented here offer a mixed picture of a diverse array of environmentally-oriented industry segments growing modestly even as a sub-set of clean energy, energy efficiency, and related segments grow much faster than the nation (albeit from a small base) and in

ways that are producing a desirable array of jobs, including in manufacturing and export-oriented fields.

As to what governments, policymakers, and regional leaders should do to catalyze faster and broader growth across the U.S. clean economy, it is clear that the private sector will play the lead role, but governments have a role too. In this connection, the fact that significant policy uncertainties and gaps are weakening market demand for clean economy goods and services, chilling finance, and raising questions about the clean innovation pipeline reinforces the need for engagement and reform. Not only are other nations bidding to secure global production and the jobs that come with it but the United States currently risks failing to exploit growing world demand. And so this report concludes that vigorous private sector-led growth needs to be co-promoted through complementary engagements by all levels of the nation's federal system to ensure the existence of well-structured markets, a favorable investment climate, and a rich stock of cutting-edge technology—as well as strong regional cast to all efforts.

Along these lines, the report recommends that governments help:

- **Scale up the market by taking steps to catalyze vibrant domestic demand for low-carbon and environmentally-oriented goods and services.** Intensified "green" procurement efforts by all levels of government are one such market-making engagement. But there are others. Congress and the federal government could help by putting a price on carbon, passing a national clean energy standard (CES), and moving to ensure more rational cost recovery on new transmission links for the delivery of renewable energy to urban load centers. States can adopt or strengthen their own clean energy standards, reduce the initial costs of energy efficiency and renewable energy adoption, and pursue electricity market reform to facilitate the use of clean and efficient solutions. And localities can also support adoption by expediting permitting for green projects, adopting green building and other standards, and adopting innovative financing tools to reduce the upfront costs of investing in clean technologies

- **Ensure adequate finance by moving to address the serious shortage of affordable, risk-tolerant, and larger-scale capital that now impedes the scale-up of numerous clean economy industry segments.** On this front Congress should create an emerging technology deployment finance entity to address the commercialization "Valley of Death" and also work to rationalize and reform the myriad tax provisions and incentives that currently encourage capital investments in clean economy projects. States, for their part, can supplement private lending activity by providing guarantees and participating loans or initial capital for revolving loan funds targeting clean economy projects using new or improved technologies. And for that matter regions and localities can also help narrow the deployment finance gap by helping to reduce the costs and uncertainty of projects by expediting their physical build-out, whether by managing zoning and permitting issues or even pre-approving sites

- **Drive innovation by investing both more and differently in the clean economy innovation system.** With the needed major scale-up of investment levels unlikely for now, Congress at least needs to embrace continued incremental growth of key energy and environmental research, development, and demonstration (RD&D) budgets. At the same time, Congress should continue its recent institutional experimentation through measured expansion of such recent start-ups as the Energy Frontier Research Centers, ARPA-E, and Energy Innovation Hubs programs. Two worthy additional experiments would be the creation of a water sciences innovation center and the establishment of a regional clean economy consortia initiative. States can also advance the clean economy through maintaining and expanding their own RD&D efforts, perhaps by tapping state clean energy funds where they exist. All should be focused and prioritized through a rigorous, data-driven analysis of the nature, growth, and strengths of local clean economy innovation clusters

In addition, the "Sizing the Clean Economy" emphasizes that in working on each of these fronts federal, state, and regional leaders need to:

- **Focus on regions, meaning that all parties need to place detailed knowledge of local industry dynamics and regional growth strategies near the center of efforts to advance the clean economy.** While the federal government should increase its investment in new regional innovation and industry cluster programs such as the Economic Development Administration's i6 Green Challenge, states should work to improve the information base about local clean economy industry clusters and move to support regionally crafted initiatives for advancing them. Regional actors, meanwhile, should take the lead in using data and analysis to understand the local clean economy in detail; identify competitive strengths; and then move to formulate strong, "bottom up" strategies for overcoming key clusters' binding constraints. Employing cluster intelligence and strategy to design and tune regional workforce development strategies will be a critical regional priority

* * *

The measurements, trends, and discussions offered here provide an encouraging but also challenging assessment of the ongoing development of the clean economy in the United States and its regions. In many respects, the analysis warrants excitement. As the nation continues to search for new sources of high-quality growth, the present findings depict a sizable and diverse array of industry segments that is—in key private-sector areas—expanding rapidly at a time of sluggish national growth. With smart policy support, broader, more rapid growth seems possible. At the same time, however, the information presented here is challenging, most notably because the growth of the clean economy has almost certainly been depressed by significant policy problems and uncertainties.

In that sense, what is most challenging here is the fundamental question raised by the dynamic growth but modest size of the most vibrant and promising segments of the clean economy.

That question is: Will the nation marshal the will to make the most of those industries?

In the end, it is a question raised frequently by these pages.

INTRODUCTION

The "green" or "clean" or low-carbon economy—defined as the sector of the economy that produces goods and services with an environmental benefit—remains at once a compelling aspiration and an enigma as the nation and its regions search for new sources of growth.

As a matter of aspiration, no swath of the economy has been more widely celebrated as a source of economic renewal and potential job creation.

Again this year President Obama spoke in his State of the Union Address of "the promise of renewable energy" and environmental pursuits that will strengthen our security, protect our planet, and create countless new jobs for our people."

Likewise, scores of nations, dozens of states, and hundreds of U.S. regions and localities continue to beat the drum for the economic, security, and environmental benefits of clean and green industry development.

Most notably, a global "race to clean" has now emerged, with numerous nations working to drive low-carbon and environmental industry growth.

China—which now produces half of the world's wind turbine and solar modules—recently announced it would accelerate its "clean revolution" over the next five years and has set out aggressive growth plans for strategic emerging industries (SEIs) critical to economic restructuring, including multiple new energy categories, electric vehicles, and energy efficiency products.[1]

Japan, in response to the Fukishima nuclear accident, has committed to achieving massive price reductions for solar

generation as part of a new renewables-oriented energy policy that will drive economic change through massive investments and yet-to-be-determined innovation.[2]

And, for its part, Britain's Conservative-led coalition government recently outlined plans for the world's first state-backed green investment bank aimed at laying the foundation for clean industry growth.[3]

In short, while the emergence of the green or low-carbon economy originally flowed from environmental concerns, a market vision now prevails—a vision in which new jobs and industries flow from the drive to reduce the environmental impacts of the economy.

Along these lines, momentum for the business of "green" flows in part from the $154 billion in private capital invested worldwide in 2010 in renewable energy alone (up 650 percent from 2004) and, looking forward, from the projected tripling to $2.2 trillion by 2020 of the broader world low-carbon energy market.[4] Or as Dow Chemical Company CEO Andrew Liveris wrote recently: "A renaissance is within reach. If Americans are the ones who design and build the new [clean economy] technologies it will re-energize commerce in the United States, creating, without a doubt, millions of high-paying jobs."[5]

Such is the current form of the "green" economy aspiration.

And yet, for all that the clean economy also remains an enigma: hard to assess. Not only do "green" or "clean" activities and jobs related to environmental aims pervade all sectors of the U.S. economy; they also remain tricky to define and isolate—and count.

The clean economy, in this regard, is not only, or even mostly, a matter of dramatic and highly visible wind farms and solar parks. It also includes barely visible "green" variants of existing industries like food and appliance manufacturing along with industries such as sewage treatment or recycling whose environmental activities are so mundane as to be barely noticeable.

But above all, the clean economy has also remained elusive because—in the absence of standard definitions and data—strikingly little is known about its nature, size, and growth at the critical regional level where it comes to ground.

Currently no comprehensive national database exists on the spatial geography of the clean economy and its sub-industries, although important work has assessed the clean economy across states.[6] And while numerous studies have analyzed individual regional clean or green industries, a proliferation of definitions and the absence of data for large numbers of regions has made it difficult to situate regional clean economies in a national and comparative context. The upshot has been that national, state, and regional economic development actors of all kinds are largely without the high-quality, consistent, fine-grained data they need to set strategy and develop initiatives to advance the clean economy.

The result: Debates about the so-called "green" economy and "green jobs" have frequently been short on facts and long on speculation, assertion, and partisanship.

Hence this report: Seeking to address some of these problems, the Metropolitan Policy Program at Brookings worked with Battelle's Technology Partnership Practice to develop a detailed database of establishment-level employment in a sensibly defined assemblage of clean economy industries covering every county in the United States over the years 2003 to 2010. In that fashion, the pages that follow represent the first study of the U.S. clean economy to provide timely information that is both comprehensive enough in its scope and detailed enough in its categorization to inform national, state, and regional leaders on the recent employment dynamics of the U.S. low-carbon and environmental goods and services super-sector as they are transpiring in individual U.S. regions and metropolitan areas. Moreover, to begin promoting a greater continuity with other information, the definitions and measurements here anticipate the approach and structure of the federal government's own forthcoming "green economy" count, due sometime next year at broader levels of geography.

What does the inquiry find? Overall, the analysis depicts a clean economy that encompasses a modest-sized but growing and layered mix of diverse industries that varies widely in its distribution across U.S. metropolitan areas. To the growth question, while the clean economy's aggregate employment growth remained modest in the 2000s (current clean economy employers added nearly half a million jobs between 2003 and 2010), young, high-profile renewable energy, energy efficiency, and related industries delivered hyper-growth, albeit from relatively small bases.

Turning to the nature of the super-sector's jobs, the new data confirm that the clean economy is in fact delivering on hopes that it would generate a diverse array of quality positions that are at once more export- and more production-oriented than is the rest of the economy. Clean economy jobs tilt toward manufacturing and exporting and provide more opportunities with better pay for lower-skilled workers. At the same time, a cadre of highly trained innovators—scientists, engineers, architects—are also disproportionately demanded by the clean economy.

Beyond that, one of the most important findings of this report has to do with the growth-promoting role of regional industry concentrations. Job growth in the clean economy has been significantly faster in regional industry clusters than elsewhere. This means that understanding the region-by-region variation of the clean economy—whether in Albany or Little Rock or San Francisco—is not just an "interesting" bit of local color but critical for understanding the competitive strengths and potential of the clean economy wherever it is found. Gaining a sharper understanding of the nature and working of these concentrations can help national, state, and regional decision-makers identify centers of strength and focus strategies and investments for maximum growth in a time of limited resources.

So this report aims also to help clarify some of what has remained opaque about the nation's and its regions' clean economy.

To that end, the report begins by noting why the metropolitan clean economy matters and then proceeds to describe the definition, methods, and data used here to measure the clean economy nationally and across various levels of geography, with a focus on the 100 largest U.S. metro areas. After that, the report reviews a series of measurements and trends that characterize the development of the clean economy across the nation and its regions. Finally, the report discusses those trends, and concludes by commenting on a number of policy problems that may be slowing the growth of the clean economy and suggesting some priorities for federal, state, regional, and private-sector work to advance clean economy growth.

In the end, the main takeaway is simple: The clean economy, as it stands today, is not a myth. It is real, ubiquitous, and growing—in some segments rapidly. And yet, for all that, too little is clearly known about the sector, which remains nascent, and which has not profited from the sort of policy environment that would best catalyze its growth. For all of those reasons, it is time to assemble the facts and decide as a nation of regions how best to make the most of the emergence of the clean economy.


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II

WHY THE METROPOLITAN CLEAN ECONOMY MATTERS

There is no doubt that the "clean," or "green," economy looms large in global, national, and regional economic debates.

But why? Why should this particular swath of establishments, firms, and industries matter inordinately to national and metropolitan leaders?

Further, what is so important about the metropolitan clean economy?

There are multiple answers to these questions—including the possibility that the future growth of the clean economy will be sizable—but the most important ones involve the interconnection of these industries with some of the most fundamental issues of present day economic life.

The clean economy matters because its emergence responds to critical global and national environmental, security, and economic trends.

To begin with, the clean economy merits attention because its growth responds to worldwide megatrends associated with critical national and world challenges—notably the growing demand for global environmental sustainability, the sharpening need for resource security, and the aspiration everywhere toward economic transformation.[1]

Global demand for environmental sustainability. The clean economy matters, first of all, because its emergence reflects a growing demand for environmental sustainability given growing concerns about the already massive scale of global and national environmental deterioration.[2]

At the global scale, steady population growth is exerting increasing pressure on scarce resources. A dozen years after reaching 6 billion people, the earth's population will grow to 7 billion later this year, probably 9 billion before 2050, and over 10 billion by 2100.[3] Over the same period, economic development and the growing wealth of rising nations will propel over 1 billion more people into the global middle class. These new, mostly urbanized consumers will purchase energy-intensive goods like appliances and automobiles for the first time, upgrade towards land- and water-intensive diets comprised of more meat and fewer basic staples, and generate increasing amounts of waste—all placing new pressures on world resources.[4]

An already stressed planet will be further strained in coming decades. On the water front, the U.N. reckons that after growing at a steady rate of 2 percent per year for the past half century, global demand for water has posted a long-term step change increase and will grow at 3 percent per year into the future.[5] Consulting firm McKinsey & Co. sees a 40 percent shortfall between existing water supplies and projected demand in 2030 absent efficiency gains.[6] Global energy consumption, for its part, is projected to increase perhaps 50 percent in the years to 2035.[7] Yet if catastrophic climate change is to be averted, greenhouse gas (GHG) emissions from the combustion of conventional fossil fuels must be *reduced* substantially.[8]

Which points to another environment-related driver of clean economy growth: the likelihood of more and more stringent regulatory responses to the sustainability challenge around the world. Notwithstanding the collapse in late 2009 of efforts to craft a single global agreement to reduce GHG emissions and the foundering of congressional efforts to institute a "cap and trade" carbon pricing

system, unprecedented national emission reduction targets were agreed to by over 75 countries at varying stages of development (including the United States) as part of the scaled-back Copenhagen Accord.[9] Nations and major states in the United States have enacted no fewer than 293 binding and accountable new emissions reduction commitments since June 2008.[10] Looking forward, continued environmental concern in the United States and around the world will almost certainly motivate the adoption of additional environmental standards that will sharpen demand for low-carbon or environment-friendly goods and services.

The bottom line: Environmental stress and policy responses to it are driving and will continue to drive waves of industrial change. Just as the growth of a post-war environmental consciousness (reflected in the Clean Air and Water Acts in the U.S.) drove the emergence of a first generation of clean economy industries such as recycling, pollution control, and remediation, concern about global sustainability and climate change are spurring the growth of a new set of energy related industries today—with more change inevitable.[11]

The largest 100 metros contain 63 percent of the nation's residential structures, 64 percent of the nation's vehicle miles traveled, and account for 56 percent of the nation's carbon emissions.

A sharpening need for resource security. The clean economy also matters for reasons of resource security: It reflects new demands that this nation and others reduce their vulnerability to resource supply shocks and related conflict.[12]

Currently, the United States consumes nearly 19 million barrels of oil per day—half of it imported—to power its economy, move its people and products, and manufacture its goods.[13] That leaves the entire U.S. economy vulnerable to geopolitical instability and supply disruptions abroad.[14] For example, the high and volatile energy prices of 2008 warned of a new, tighter, and more uncertain reality on the world market for fossil fuels, particularly oil.[15] Today, economic recovery, the return of oil prices to over $100 per barrel, and the Arab Awakening's uncertain course in the Middle East and North Africa have only sharpened these concerns. And rightly so: Such uncertainty and price volatility has been shown to reduce investment across the economy, increase business costs, disrupt household budgets, and so depress domestic growth.[16]

However, the "green" and low-carbon goods, processes, and services being developed by the clean economy represent an opportunity for the nation to insulate itself from price and supply shocks and begin to disentangle itself from the messy geopolitics of oil through efficiency advances and a diversification of the nation's energy-source portfolio.[17]

In this connection, environmentally-oriented technologies and processes will likely contribute to resource security by reducing the environmental impact of exploiting the fossil fuels that are already abundant in energy-hungry countries like the U.S. and China, such as coal and shale gas—making uptake manageable by mitigating their adverse effects. Coal will remain an important source for generating electricity well into the future so it is likely that end-of-pipe mitigation technologies and carbon capture and sequestration systems will emerge as critical aspects of its use. Likewise, water and drainage treatment technologies are already seeing significant new demand associated with managing the substantial flows of contaminated "process" water generated by the hydraulic fracturing techniques used in extracting gas and oil from shale deposits.[18]

Paralleling these dynamics are stresses involving the world's water resources. Water security threatens to become a flashpoint in many already volatile regions of the world where supplies are at once scarce (the Middle East), facing significant pressure in demand (South and East Asia), and vulnerable to a changing climate (everywhere).[19] Since agriculture soaks up 70 percent of the water consumed globally, changes in water supply—which will be how climate change most tangibly affects daily human activity—will have direct and global effects on food security.[20] Exacerbating the issue, much of the population growth mentioned above will take place in regions with already overburdened or underdeveloped water infrastructure.[21] Yet here, too, the water-related industries of the clean economy hold out the hope of minimizing shortfalls (and so conflict) and securing supplies through efficiency gains and advancements in purification, management, and recycling technologies.[22]

A world-wide aspiration toward economic transformation. Finally, there remains a third increasingly ascendant factor behind the clean economy's significance: the prospect of industrial transformation. The clean economy matters, in short, because it interacts with nearly every aspect of the rest of the economy and is emerging as a site of rapid technological and process innovation world-wide.

Innovation, after all, remains a crucial driver of economic growth, and so clean economy innovation—motivated by the unprecedented environmental and resource challenge outlined above—appears a likely source of future economic development as firms of all kinds seek to invent new, environmentally friendly ways to decrease the world's carbon and resource intensity.[23]

In fact, the likelihood of transformation is already attracting investment. Some $1 trillion in investment capital globally flowed into clean energy segments alone between 2004 and 2010, as yearly investment levels nearly quintupled from $52 billion to $243 billion.[24] Looking forward, a recent survey by Ernst & Young found that three-quarters of major global corporations plan to increase their "cleantech" budgets from 2012 to 2014 and that 40 percent of that spending will flow into R&D.[25] Turning to water, the prospect of innovation is also attracting increased investor attention. Most notably, venture capital (VC) firms poured nearly $1.25 billion into the historically staid sector between 2005 and 2010 through close to 250 separate deals.[26]

In this regard, one of the most important heralds of both present and future innovation potential and economic transformation may be VC investment. VC backed firms are roughly three to four times more innovative (as measured by their patent production) than their counterparts that receive

other forms of private investments and as it happens clean economy companies are increasingly in the sights of VCs.[27] Between 1995 and 2010, the share of U.S. VC dollars flowing to clean economy concerns increased from 2 percent in 1995 to 16 percent in 2010.[28] Looking forward, analysts predict increasing shares of global and U.S. VC investment to flow into clean economy technologies.[29]

Even now the pace of innovation has picked up in many clean economy sectors, and with it the possibility that the clean economy will create future jobs as well as new climate-friendly goods, services, and processes. On this front, patenting tells the story. According to the Organization for Economic Cooperation and Development (OECD), patent applications filed at the European Patent Office (EPO) related to the clean economy rose from 4.6 percent of all patents in 1987 to 7.4 percent in 2007, such that by 2007, over 9,000 clean economy patent applications were being filed annually, just at the EPO. Some 17 percent of these patents originated with U.S. inventors.[30]

In short, the clean economy increasingly looks like a promising location for the emergence of significant new technologies, processes, and industries that will shape the next economy and generate new jobs. That dozens of the world's nations ranging from Brazil and China to South Korea and Turkey are investing heavily in such development both reinforces the emerging consensus and underscores that the "race to clean" has become an urgent competition among states for the resource productivity, jobs, and export-oriented manufacturing that will come with it.[31]

The metropolitan clean economy matters because that's where the clean economy is being built, firm by firm and cluster by cluster.

But why, then, does the metropolitan or regional clean economy matter inordinately? The reason has to do with the special importance of geography in economic life.

Regions contain, aggregate, and amplify the key "drivers" of innovation and economic dynamism.[31] Far from being placeless, the economy—and economic change—is place-based. In this respect, the clean economy—like the rest of the economy—is neither disembodied nor "flat," but concentrates in particular places.[33]

This concentrated reality of the national and the clean economies is first of all arithmetic. Just as the 100 largest U.S. metropolitan areas encompass two-thirds of the nation's population but three-quarters of the nation's economic output, such places contain and add up key pluralities of the nation's clean economy markets and inputs.

The largest 100 metros contain, for example, 66 percent of the nation's population, 63 percent of the nation's residential structures, and 64 percent of the nation's vehicle miles traveled while accounting for 56 percent of the nation's carbon emissions.[34] As such, these regions represent the nation's prime users of public water, electricity, and fuel; stand as the core generators of wastes and pollution that must be remediated; and so represent a prime global market for air and water management, energy efficiency goods and services, building retrofits, renewable energy, low-carbon transportation solutions, and the smart systems needed to run them. Already, 73 percent of the nation's LEED certified green buildings stand in the nation's top 100 metro areas.[35]

More than major markets for clean economy goods and services, however, the nation's largest metro areas aggregate the key inputs to clean innovation. Two-thirds of the nation's major research universities and environmental science and energy doctorate programs reside within the 100 largest metropolitan areas as do three-quarters of the nation's workers with degrees in science and engineering.[36] Likewise, 48 out of nation's 83 top environmental sciences and energy research laboratories operate there.

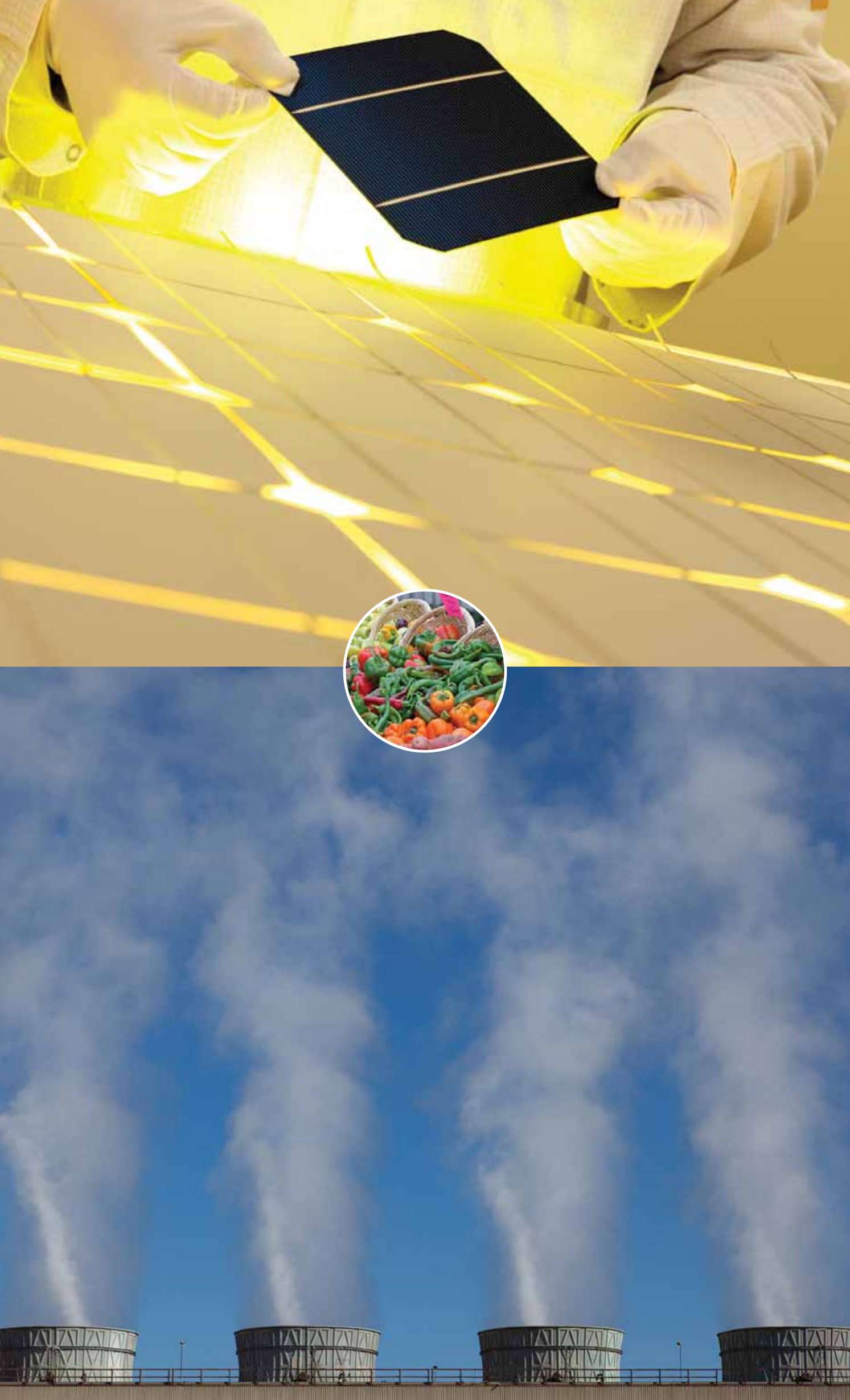
At an early stage of the commercialization pathway, no fewer than 96 of the 119 companies and research organizations that have so far won grants from the Advanced Research Projects Agency—Energy (ARPA-E) for cutting-edge clean energy research projects are based in the largest U.S. metros.[37] Farther along the path, Department of Energy (DOE) loan guarantees have also flowed heavily to metropolitan centers of commercial activity and deployment. Some 86 percent of this financing has flowed to the 21 projects (out of 30 total) located in the 100 largest metro areas.[38] On the environmental side, 65 percent of Small Business Innovation Grants administered by the Environmental Protection Agency flowed to the top 100 metros.

These results reinforce U.S. economic geography. The 100 largest metropolitan areas are the nation's innovation engines, generating some 78 percent of the nation's green patents.[39] Their dynamism, moreover, means that 54 of the 58 highest-impact U.S. cleantech firms called out in the 2010 Global Cleantech 100 list are based in the 100 largest U.S. metropolitan areas. (Going further, 39 of the 58 are headquartered in just four metros characterized by vibrant clean economy industry clusters—Boston, San Francisco, San Jose, and Los Angeles).[40]

In short, metropolitan areas, large and small, are now and will increasingly be the nation's critical centers of clean economy talent, innovation, and finance and so its top hubs of commercialization, deployment, and trade.

Regions and metropolitan areas, in short, are not a part of the national clean economy; they *are* that economy, as Alan Berube has written.[41]

For all of its significance, though, rather little is known about the size and shape of the clean economy, especially at the regional level. "Sizing the Clean Economy" is one response to that gap.



III

DEFINING AND MEASURING THE CLEAN ECONOMY IN U.S. METROPOLITAN AREAS

Whatever the terminology, the "clean" or "green" or low-carbon economy prompts almost as much confusion as it does curiosity and fascination. One reason: Defining it and measuring it have proven extraordinarily difficult.

Literally hundreds of disparate studies of the clean or green economy exist. In fact, the California Employment Development Department requires 24 pages in a recent digest to list all of the studies it tracks on the clean economy.[1] Many of these studies focus on individual states. Others create national data using various methods. And many of the analyses employ varied definitions of this heterogeneous sphere of economic activity. For their part, the state- or region-specific studies provide detailed information but usually can't be compared across geographic units to place states or metropolitan areas in the national context. At the same time, the national studies either ignore sub-national geography or only provide information at a very high level of aggregation.

Hence, what follows is the first study of the U.S. clean economy to provide consistent and timely information that is both comprehensive enough in its scope and detailed enough in its categorization to inform national, metropolitan, and even local leaders on the recent dynamics of the U.S. low-carbon and environmental goods and services super-sector—with particular emphasis on regional growth and evolution.

Similarly, the pages that follow extend a large body of work at the Brookings Metropolitan Policy Program on the nature of the emerging "Next Economy" in the United States.[2] This work has focused on the possible underpinnings of future U.S. growth and moved to investigate the contention that the "next" U.S. economy needs to be more export-oriented, lower-carbon, and innovation-driven as well as opportunity rich. Key methodological decisions in developing this report were made with those preoccupations in mind. Further details are available in a detailed methodological appendix that is available separately from this report at the "Sizing the Clean Economy" project page on the Brookings website (http://www.brookings.edu/metro/clean_economy.aspx).

DEFINITIONS AND CATEGORIES

While there is no consensus on a definition of the clean economy, there are many points of agreement. Moreover, various studies have openly and thoughtfully addressed the difficulties involved. In advancing a definition of the clean economy, therefore, this report seeks to align itself with well-established guidelines and precedents while laying out rules that are simple, internally consistent, transparent, and replicable.

The basic definition of the clean economy used in this study runs 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.

To elaborate on this relatively succinct and conservative definition, a few words are in order on the precedents, terms, and approach employed here.

First, it bears noting that the language and distinctions used here draw heavily from both European and U.S. government statistical precedents. Most notably, key aspects of the present definition, categorization, and approach draw from previous definitional and measurement work by Eurostat and the Organization for Cooperation and Development (OECD) as well as by the U.S. Environmental Protection Agency (EPA) and the U.S. Bureau of Labor Statistics (BLS), which will next year release its own measurement of the "green" economy.[3] In that sense this measurement has sought continuity with other authoritative research rather than newness.

Second, it is also worth noting that this is an economic development study focused tightly on clean economy business establishments and the jobs they create. To elaborate on this orientation, this report is primarily about the establishments and jobs of U.S. enterprises whose products have an environmental benefit, including those that add value as part of the clean economy supply chain. Given that, the report does not attempt to measure jobs in companies that conduct themselves in an environmentally-friendly manner. Rather, it insists that companies and establishments sell, or in the case of the public sector, provide products or services with an environmental benefit (either inherently, like environmental remediation services or relatively, like organic food or solar panels). For example, no effort was made here to count companies that adopt internal environmental goals, reform their processes to make them more environmentally responsible, or even contribute to general public knowledge about environmental issues. However valuable these activities are, this study excludes the jobs related to those activities from the clean economy. They could be thought of as "clean process" jobs, as opposed to "clean production" jobs.[4]

As stipulated above, moreover, a product must benefit the environment to be deemed "clean." This is consistent with the BLS standard for its clean production survey, and it is a slight variation on the Eurostat standard which mandates an environmental purpose.[5] The environmental benefits include preventing or minimizing pollution (including greenhouse gas emissions), or natural resource depletion, or managing natural resources, including energy, air, and water, for greater efficiency, conservation, or protection.

The last part of the above definition—regarding companies that add value to clean economy products—is intended to capture the relevant aspects of the clean supply chain. 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 has been to only include the establishments of companies that add value uniquely to clean products, whether by supplying a special 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 require skills that distinguish those services from traditional maintenance work or roofing.

Finally, some industry and impact studies estimate "direct" and "indirect" employment. By contrast, this study measures only employment in establishments that directly produce goods and services with environmental benefits, or produce uniquely tailored goods and services that add value to products with an environmental benefit. Studies of "indirect" jobs, for their part, use information on cross-industry purchases to claim that one industry stimulates the creation of jobs in another. This method is useful for regional impact studies that estimate the effect of business relocations and national impact studies that estimate the effect of government stimulus during a downturn. In both cases, the source of added revenue can be thought of as external and temporary. However, such an approach is not appropriate for a study like this one where there is no external source of revenue. No establishment generates its own revenue out of nothing, and so every direct job is some other industry's indirect job.

Consequently, the job totals reported here will be lower than many studies which include "indirect" jobs. This isn't to deny that clean economy firms are involved in rich networks of business relations with traditional "non-clean" firms; it is simply to say there is no reason to think of these general suppliers or customers as components of the clean economy sector.

This approach has the advantage of being firmly rooted in economic activity connected to supply and demand in competitive markets, rather than just voluntary business philanthropy. This focus, along with a "direct" jobs count from actual companies, makes the measurements akin to industry data from government agencies and provides the sort of straightforward information needed for strategic thinking about investments.

MEASUREMENT AND DATA

With the definition and method settled, the Brookings-Battelle team proceeded to measure the clean economy by building a database of clean economy companies and establishments "from the ground up." That is, instead of doing a national survey, which would be extremely costly if it were to be locally representative and require an array of difficult assumptions about sampling, the team took on the task of identifying and locating every company (and ultimately establishment) in the clean economy that could reasonably be identified using a variety of validated public and proprietary data sources.

Normally, standard industrial codes would be used for such a measurement exercise, but because the clean economy pervades so many industries, many codes contain establishments that fall both inside and outside the clean economy while at the same time no existing industry classification system breaks out green industries, whether it be solar energy activities, energy efficient products, green materials production, or enterprises aimed at the reduction of greenhouse gases. Or as the BLS explained in its March 16, 2010 Federal Register notice on approaches to measuring the green economy: "The studies reviewed showed that neither of the standard classification systems used in the BLS data, the North American Industry Classification System (NAICS) or the Standard Occupational Classification (SOC), identifies a green or environmental grouping of industries or occupations."

The upshot: Company and ultimately establishment-specific information was needed to identify and quantify clean economy establishments and employment.

Identifying clean economy companies and establishments

Two approaches were taken to identify clean economy firms. First, a set of industries deemed exclusively part of the clean economy was identified using the eight-digit SIC (Standard Industrial Classification) system developed by the business intelligence firm Dun & Bradstreet (D&B) and maintained as a time series by Walls & Associates as the National Establishment Time Series (NETS).[6] In performing research on the clean economy for the Pew Charitable Trusts, Collaborative Economics developed a list of industries that could be considered completely embedded in the clean economy, in that each establishment in that listing produces goods or services that have an environmental benefit as defined above. More recently, Berkeley researchers worked off that list and added over 100 new SICs to it.[7] This study used the Berkeley list as a starting point and incorporated almost every company, establishment, and job in those industries and added relevant SICs for air, water, waste management and treatment.[8] This industry-based approach yielded 49 percent of all jobs and 69 percent of all establishments included in this study (see external appendix for full list).[9]

The second approach employed for identifying clean economy firms and establishments was to create a validated master clean economy list to catalogue every known industry association, certification, federal grantee, venture capital recipient, patent assignee, and product list that is relevant to the clean economy. In this fashion, over 60 lists of clean economy companies (see the appendix) were compiled to create a substantial list of firms. The team also considered and incorporated listings from market research organizations and proprietary industry data sources, such as the Environmental Business Journal and Plunkett's Renewable, Alternative and Hydrogen Energy Industry Almanac. All of the lists were carefully validated. Lists were rejected if the team discovered that non-clean economy companies were allowed to join. The companies from the master list were incorporated into the study, and duplicate establishments were removed.

With the industry codes identified and firm lists assembled, the next step was to find statistics on the companies and their relevant establishments using Dun & Bradstreet. Establishment history and other characteristics were added through the use of NETS.

For companies that produce both "green" and "non-green" products an effort was made to include only establishments that specialize in the clean economy production. This task was facilitated by Dun & Bradstreet and NETS because they employ detailed industry classification schemes that distinguish activities across establishments of the same company and even within single locations.

For cases where large establishments were known to produce both green and conventional products, information from companies, including their websites, was used to allocate a percentage of the site's employees to the clean economy based on the relative importance of its clean products compared to all of its products. Because of the nature of the Dun & Bradstreet database, many of the smaller establishments of less than five employees were a mix of independent contractors and field offices rather than stand-alone establishments. In order to ensure consistency within the establishment and job count, those very small establishments were excluded from the Brookings-Battelle database. This resulted in a roughly five percent reduction in the total number of clean economy jobs and a larger reduction in the number of establishments as most of them had zero jobs. (See appendix for details).

Classifying the establishments

Once the company, establishment, and job information was compiled, the next step was to classify it. The goal was to make the data as analytically useful as possible to facilitate research at various geographic levels and especially for regional economic development planning. There were a number of options, and ultimately this study reports the data in three ways.

First, through Dun & Bradstreet and NETS, the data is organized by NAICS categories, which is how the U.S. government reports data (e.g. for manufacturing, construction, financial services, and so on). Second, because only a small fraction of NAICS categories reside within the clean economy, a second scheme was adopted that divided establishments into five high-level categories (largely adopted from the BLS). Finally, to provide a third, finer-grained categorization, 39 segments designed by the Brookings-Battelle team was used to further narrow the class of business activity and allow for detailed analysis.[10] Establishments were assigned to segments based on their industry code, the list used to identify them, or, in some cases, information provided by the company's website.[11] The external methods appendix presents a table that shows how the company lists were matched up to segments.

Other measures

A series of other measures were created using the clean economy database. Details on how these were calculated are available in the appendix document. A quick description follows:

Because of the way companies were identified—using member lists, grantee lists, and so on—no way existed for recreating the same universe of clean economy firms in previous years. Yet, the employment history of firms currently existing—including when they were born—was available through NETS from 2003 to 2009 (with D&B data providing the most current 2010 jobs figures—as downloaded in early 2011). This created a problem when calculating **growth rates**: The base year was artificially higher than it would otherwise be because the database contained no record of job losses from establishments that went out of business (only those that laid off workers). This is fine when comparing segments, states, or MSAs, because the bias is shared more or less evenly, but it won't work for comparisons against the "non-clean" national economy. To adjust U.S. growth from 2003 to 2010 for the loss of jobs from closing establishments, information was obtained from the Bureau of Labor Statistics' Business Employment Dynamics series and the NETS.[12] The national base year

Table 1. Brookings-Battelle Clean Economy Industry Categories and Segments

Brookings-Battelle Category	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

could then be adjusted to calculate what growth would have been nationally if no jobs were lost from establishments that closed. The job growth figures reported in this report reflect this adjustment, and therefore are higher than actual net growth rates.

Exports from each establishment were estimated by allocating national exports for a given three or four-digit NAICS industry to establishments based on the establishment's share of total U.S. employment in that three or four-digit industry. A similar approach was applied to metropolitan areas in recent Brookings research and is described in detail in that report.[13] The same sources and techniques were used here.

Data on the number of **occupations**, type of occupations, **wages**, and education requirements for each job were calculated using national statistics from the BLS's Occupational Employment Statistics (OES) program and Employment Projections Program (EPP).[14] OES provides estimates for the number and type of occupations in each four-digit NAICS, and EPP provides education attainment estimates for each occupation. Occupations that fell within the middle range of the median wage distribution were classified as moderate-wage "green collar" pursuits.

Establishments were identified as **clustered** if they were located in a county with a significant number of jobs in other establishments in the same segment. The threshold was whether or not the number of other-establishment jobs in a county's segment was greater than one percent of the U.S. jobs for that the segment. Other definitions—including the use of relative shares—yielded similar results.

LIMITATIONS AND CHECKS

While the goal of this report was to measure every establishment and job in the clean economy, that is clearly an impossible task. The study surely left out many companies that are rightfully part of the clean economy, and there is no doubt that the employment figures and location data from Dun & Bradstreet and NETS will not always exactly match the real world.

One reason for this is the fact that for whatever reason some clean economy companies fail to appear on any of the lists used to compile the bulk of the database.

Take the car-sharing business, for example, which claims to reduce the demand for cars and the consumption of gas through its convenience and fuel-efficient car-sharing fleets.[15] These assertions are supported by academic research on car-sharing.[16] Critics could counter that car-sharing encourages driving over more environmentally-friendly public transportation, and there is evidence that car-sharing

is more common where public transit is readily available.[17] But whatever its true environmental impact, no car-sharing company is in this database. The reason is that they did not win any clean economy grants, join any green industry associations, obtain any green certifications, develop any clearly identifiable green economy patents, or receive money from a cleantech venture fund. There are surely other companies that many people would consider to be "green" that likewise did not make it into this database for the same reason.

With these caveats in mind, there is compelling evidence that the Brookings-Battelle clean economy database provides a reasonably accurate estimation of the clean economy.

To assess and improve accuracy, a preliminary version of this 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, by their judgment, mistakes in the database including, especially, clean economy firms that were left out of the Brookings-Battelle database. Some of these research partners embarked on extensive efforts of data collection, including interviews with local industry leaders and analysts. Where significant oversights or discrepancies were identified the Brookings-Battelle team redoubled its efforts to locate new lists with broader coverage of those sectors that were originally under-counted. The resulting effort added several hundred thousand jobs to the database. This process was repeated on several occasions.

To get a general sense of the accuracy of the final database, one can compare it to other studies of the clean economy. In this fashion, the Brookings-Battelle database contains 2.7 million jobs. This figure runs to the higher end of recent estimates but lies within the range reported by the U.S. Department of Commerce in a recent report. For that matter it is three to five times higher than national estimates produced in recent years by the Pew Charitable Trusts and the U.S. Conference of Mayors.

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.[18] Estimates by a state agency for Washington in 2008 were roughly half of the Brookings-Batelle estimates but after a methodological change the 2009 edition of the survey yielded a jobs number 19 percent higher than the Brookings-Battelle estimates.[19] Two states—Missouri and Kansas—came up with "direct job" estimates that were one-third to one-fourth lower than the Brookings-Battelle figures.[20] Michigan was the only state with a major green jobs survey that produced a substantially higher number than the Brookings-Battelle employment estimate.[21] 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.[22]

Finally, the Brookings team also compared job levels in this database to various industry reports. In almost every case, the industry reports—which frequently reported "indirect" as well as "direct" jobs—exceeded the present estimates. However, 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.[23] This number is slightly lower than the 29,531 estimated by Brookings and Battelle. The Solar Foundation, in conjunction with Green LMI, did a national survey suggesting that there were 93,502 solar energy jobs (mostly in California) but only 24,916 jobs in solar manufacturing.[24] This comparison reveals that the Brookings-Battelle estimates probably undercount jobs in solar installation; those workers are difficult to measure because the work is done by companies that are heavily involved in traditional construction and installation activities. For its part, the National Hydropower Association estimates that hydropower accounts for 60,000 direct jobs, compared to 55,433 estimated by Brookings-Battelle.[25] Likewise, the American Wind Energy Association estimates 30,000 direct jobs; Brookings-Battelle estimates 24,294 wind jobs.[26] And finally, the Geothermal Energy Association estimates 9,000 direct jobs, while the Brookings-Battelle figure is 2,720.[27] Overall, while not perfect matches, these comparisons suggest the database presented here is fairly reliable, though coverage of solar installers is probably lacking.

To gauge how well the database picked up specific companies, a final quality check was conducted using the Global Cleantech 100 list produced by *The Guardian* newspaper in partnership with Cleantech Group. 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.[28] Of these, 81 percent (or 47 out of 58) were included in the Brookings-Battelle database. Those missed were either not covered by Dun & Bradstreet or had fewer than five employees in the D&B record; the only exception was a car-sharing company, which did not make it on to any public list except the Global Cleantech 100.

In short, through comparisons with other national, regional, and even industry studies and refined lists of new firms like those on the Global Cleantech 100, the evidence suggests that the Brookings-Battelle method offers a reasonably accurate measure of the clean economy. National and state comparisons provide no evidence that this method has significantly undercounted the number of clean economy jobs. Indeed, most studies of comparable geographies have found many fewer jobs, and yet, the strict requirements for inclusion mean that an over-count is highly improbable.

In addition to accuracy, the "bottom-up" method utilized here makes this arguably the most comprehensive study to date. No other dataset provides such fine-grained classification and no other dataset provides national, state, and metropolitan data across the entire United States. What is more, while the forthcoming BLS green jobs study will provide some of these geographic advantages (state data will be available), it will probably not be able to disclose job numbers in many locations because of survey-participation agreements. Likewise, it will report the data at the two-digit NAICS level but will not offer the segment detail provided in the Brookings-Battelle database.

Ultimately, the two surveys should prove complementary. While the BLS survey will be valuable, it may not fully satisfy the demand from state and metropolitan actors for detailed geographic and segment information, which means existing sub-national measurement efforts, such as this study, will probably need to be continued as long as there is interest in measuring the clean economy.

In conclusion, while many studies of the green or clean economy have often seemed to play out as proxy wars in the larger debate over climate change policy, this work tries to step back from those issues. By embracing sound precedents and transparency, this effort seeks simply to deliver a reasonably accurate and locally useful measurement of the firms, establishments, and jobs in the United States that are providing goods and services related to protecting the environment, mitigating climate change, conserving energy, and generating clean power. The sections that follow analyze the data and discuss various policy implications. At the same time, for those who want to drill down on all of the jobs data, as well as selected clean economy indicators for the nation, the states, and the 100 largest metropolitan areas, that material is available for free download at the Brookings website (http://www.brookings.edu/metro/clean_economy.aspx).


KILOWATTHOURS

IV

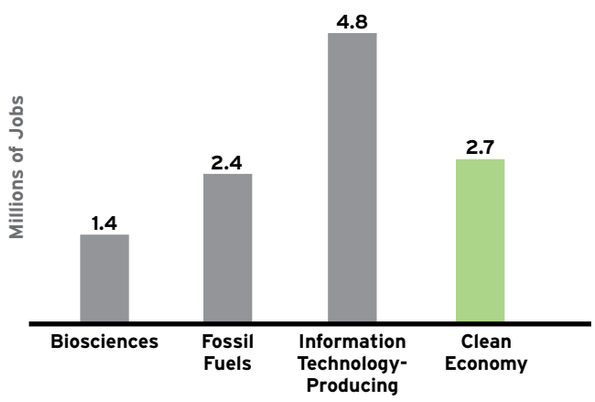
MEASURING AND TRACKING THE CLEAN ECONOMY IN U.S. METROPOLITAN AREAS

So what does this assessment of the U.S. clean economy find? This analysis of establishment-level data compiled by the Metropolitan Policy Program at Brookings and Battelle covering the entire United States and focusing on the nation's 100 largest metropolitan areas reveals a series of key takeaways:

1. The clean economy, which employs some 2.7 million workers, encompasses a significant number of jobs in establishments spread across a diverse group of industries. In 2010, 2.7 million jobs in the United States directly contributed to the production of goods and services that had an environmental benefit. The jobs were spread over 57,501 different establishments in 41,185 companies and existed in almost every industry.

Encompassing 2 percent of all positions, the clean economy represents a modest slice of the U.S. economy. By contrast, the healthcare sector—the nation's largest source of private employment—employs 13.8 million workers, and accounts for 10.2 percent of jobs.[1] Yet, compared to many other cross-industry sectors, the clean economy looks much more significant (see Figure 1). For example, just 1 percent of jobs (1.3 million) directly support the production of fossil fuel-based energy, derivative manufactured products, and machinery; that number rises to 1.8 percent (2.4 million) if all wholesale and retail distributors and transporters are included such as gas station employees.[2] Likewise, the biosciences sector—a focus of much investment interest—supports just 1.4 million employees.[3] Producers in the

Figure 1. The Clean Economy Compared with Other Sectors of the U.S. Economy



Source: Biosciences: Battelle and Biotechnology Industry Organization, "State Bioscience Initiatives 2010" (2010); Fossil Fuels: Brookings analysis of County Business Patterns and Bureau of Labor Statistics data; Information Technology: Moody's Analytics; Clean Economy: Brookings-Battelle Clean Economy Database The job levels reported here reflect data from multiple years: Biosciences from 2008; Fossil fuels from 2009; and the remainder from 2010.

Table 1. Segments of the Clean Economy

Category	Segment	Jobs, 2010
Agricultural and Natural Resources Conservation	Conservation	314,983
	Organic Food and Farming	129,956
	Sustainable Forestry Products	61,054
Education and Compliance	Regulation and Compliance	141,890
	Training	266
Energy and Resource Efficiency	Public Mass Transit	350,547
	Energy-saving Building Materials	161,896
	HVAC and Building Control Systems	73,600
	Green Architecture and Construction Services	56,190
	Professional Energy Services	49,863
	Appliances	36,608
	Energy-saving Consumer Products	19,210
	Battery Technologies	16,129
	Smart Grid	15,987
	Electric Vehicle Technologies	15,711
	Lighting	14,298
	Water Efficient Products	13,066
	Fuel Cells	7,041
Greenhouse Gas Reduction, Environmental Management, and Recycling	Waste Management and Treatment	386,116
	Professional Environmental Services	141,046
	Recycling and Reuse	129,252
	Green Consumer Products	77,264
	Green Building Materials	76,577
	Nuclear Energy	74,749
	Recycled-Content Products	59,712
	Remediation	56,241
	Air and Water Purification Technologies	24,930
	Green Chemical Products	22,622
	Pollution Reduction	9,986
	Carbon Storage and Management	391
Renewable Energy	Hydropower	55,467
	Wind	24,294
	Solar Photovoltaic	24,152
	Biofuels/Biomass	20,680
	Solar Thermal	5,379
	Waste-to-Energy	3,320
	Geothermal	2,720
	Renewable Energy Services	1,981
	Wave/Ocean Power	371

Source: Brookings-Battelle Clean Economy Database

important information technology (IT) sector do employ more workers than the clean economy—approximately 4.8 million—but almost one third of those jobs are in wholesale and retail.[4]

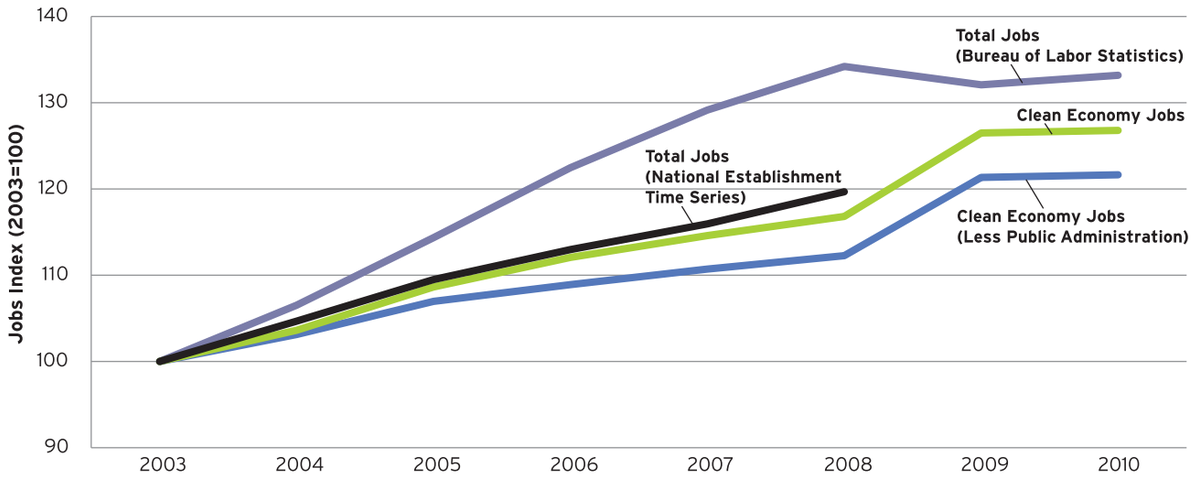
In terms of its sectoral profile, the clean economy encompasses a wide variety of activities that extends far beyond high-profile renewable energy and energy efficiency sectors. In fact, the vast majority of clean economy jobs produce goods or services that protect the environment or reduce pollution in ways that have little to do with energy or energy efficiency. Nearly one-fifth of clean economy jobs, for example, involve agriculture and conservation, which includes a variety of land and forestry management jobs, as well as those in organic farming. Another 40 percent of clean economy jobs benefit the environment through greenhouse gas (GHG) reduction, the management of resources like air and water, and recycling. Businesses involved in renewable energy, by contrast, comprise just 5 percent of all clean economy jobs. Nuclear energy, considered clean but non-renewable, comprises 3 percent of jobs: roughly 75,000.

Getting into more detail, the largest single segment of the clean economy involves waste management and treatment, which employs nearly 400,000 workers—14 percent of all clean economy jobs. Here, the U.S. Bureau of Reclamation is the largest employer, followed by the waste management and water operations of the city of Los Angeles and the city of New York. The second largest segment is public mass transit, which employs another 350,000 workers and yields an environmental benefit by displacing single-passenger vehicles. First Student Inc., a nationwide school bus operator (which displaces less efficient personal-vehicle travel), is the largest single employer in transportation, followed by the National Railroad Passenger Corporation (known as Amtrak), and the operators of the dense Northeast corridor: the Long Island Railroad and the New York and Washington, DC metropolitan transit authorities. The third largest segment is conservation, a substantial number of workers in which are employed by the U.S. Fish and Wildlife Service, the U.S. Forestry Service, and National Park Service, as well as state and local governments.

Despite their small size, meanwhile, the activities most strongly identified with the clean economy may be renewable energy production and energy-saving technologies. The largest renewable segments are hydropower, wind energy, and solar photovoltaic (PV) energy, which provide about three-quarters of all renewable energy jobs, or just over 100,000 jobs. Large firms in these segments include General Electric, Rosendin Electric, and Vestas in wind and MEMC Electronic Materials, First Solar, and Sharp in solar. Other energy-focused segments include fuel cells, smart grid, battery technologies, and electric vehicles, with many small, young firms, as well as large companies like Ball Aerospace & Technologies and 3M, key players in fuel cells; Itron and Black & Veatch Corp in smart grid; and Exide Technologies and Delphi in batteries. These segments provide some 55,000 "direct" jobs.

The rest of the green economy, finally, involves

Figure 2. Clean Economy Job Growth Compared with Overall Job Growth, Excluding Establishments That Closed, 2003-2010



Source: Brookings-Battelle Clean Economy Database, National Establishment Time Series (NETS), and the Bureau of Labor Statistics

Clean economy data was only available for establishments that were in business in 2010 and therefore data for prior years do not reflect jobs losses due to establishment closings. To be comparable, the total U.S. jobs data presented here from NETS are only for establishments that were in business in 2009, as NETS data for 2009 and 2010 was not available to the study. The total U.S. jobs data from BLS presented here were also adjusted to account for job losses due to establishment closings. To make the adjustment, the number of job losses in future years up until 2010 was subtracted from total employment in the base year, using data from the Business Employment Dynamics program.

everything from regulation and compliance (such as the EPA's activities), to research and engineering (enterprises like Oak Ridge National Lab), green architectural services, building products, and more. Over 77,000 clean economy jobs, for example, can be found in companies that make a diverse array of "green" consumer products, or those with environmentally sustainable ingredients. This includes companies—such as L'Oreal, Maybelline, Pfizer, and Johnson and Johnson—whose products have received high environment marks from the GoodGuide, an independent consumer products rating enterprise.[5]

Yet beyond these categories and segments there is one more way to think about the clean economy and that is in terms of the era of the environmental concern being addressed. In this respect, over 90 percent of clean economy jobs lie in older segments that provide goods or services that solve long-appreciated environmental problems. Many of these jobs reside in government but others populate commercial segments like lighting, water efficient products, green building materials, recycling and reuse, and pollution reduction. At the same time, though, a newer layer of establishments has emerged that is working on other environmental problems, the dangers of which have only recently been widely understood—such as global warming and the side effects of fossil fuel production. They are doing so through the creation of new forms of energy, as well as energy saving, storage, and mitigation products.

2. The clean economy grew more slowly in aggregate than the national economy between 2003 and 2010 but newer "cleantech" segments far outperformed the nation during the period, as did the clean economy overall during the recession. Overall, today's clean economy establishments added more than half a million jobs between 2003 and 2010, expanding at an annual rate of 3.4 percent. This performance somewhat lagged behind in the national economy, which grew by 4.2 percent annually over the period (if job losses from establishment closings are omitted to make the data comparable).[6] And yet, during the middle of the recession—from 2008 to 2009—the clean economy grew faster than the rest of the economy, expanding at a rate of 8.3 percent. This is likely due, in part, to the American Recovery and Reinvestment Act (ARRA), which channeled large sums of public spending towards clean energy projects through much of 2009.

In interpreting these numbers, the reader should keep in mind that the Brookings-Battelle database lacked any information on establishments that died (i.e. closed) before 2010, but was able to get establishment history for those enterprises operating in 2010 and identified as part of the clean economy. Therefore, all the clean economy job growth figures reported in this report are higher than they would otherwise be since, for example, jobs that existed in 2003 at an establishment that closed in 2005 would not have been captured by our searches in 2010—to the effect of lowering the job count in 2003. To make the data comparable, U.S. growth data is adjusted similarly, removing job losses from establishment deaths. This was done using data from NETS (through 2008) and the Bureau of Labor Statistics' Business Employment Dynamics series (through 2010). (Figure 2).

Which layers of the clean economy grew fastest? Young establishments in a few key segments drove most of the job growth. Excluding closings, 78 percent of all job gains between 2003 and 2010 came from establishments born in 2003 or later. Most new jobs are created by new enterprises across the broader economy, too, but the impact per establishment is not as marked as in the clean economy.[7] There, only 22 percent of all establishments were created in or after 2003 and yet they generated that large majority of the job creation.[8] To put this in perspective, old establishments in the clean economy (those born before 2003) created an average of just three jobs for every one establishment from 2003 to 2010 while new establishments created 37 jobs. This compares favorably to new establishments nationally which created just 10 jobs per establishment over the same period (excluding job losses from deaths).[9] The takeaway: Young establishments in the clean economy had a substantially greater job creation impact per establishment than their "non-clean" peers in the national economy.

Which segments grew fastest? Again, the youngest did. The 13 segments in which the bulk of establishments date to later than 1996 grew by 8.3 percent annually from 2003 to 2010—a figure that easily outstripped the 3.2 percent growth of older segments as well as the 4.2 rate for the national economy over the same period (Table 2).

Along these lines, four of the five fastest-growing segments during this seven-year period were in renewable energy. Solar thermal grew at a torrid pace, expanding by 18.4 percent annually over the seven years and adding

Table 2. Job Growth and Median Year of Establishment Birth by Clean Economy Segment

Segment	Absolute Change in Jobs, 2003-2010	Annual Average Change in Jobs, 2003-2010 (%)	Median Year of Establishment Birth
Wave/Ocean Power	+273	20.9	2005.5
Solar Thermal	+3,732	18.4	2001
Wind	+15,110	14.9	2004
Carbon Storage and Management	+228	13.3	2002
Solar Photovoltaic	+12,286	10.7	2005
Fuel Cells	+3,499	10.3	2000
Biofuels/Biomass	+9,296	8.9	2004
Smart Grid	+7,001	8.6	1999.5
Conservation	+121,147	7.2	1996
Professional Energy Services	+18,702	6.9	2001
Professional Environmental Services	+51,793	6.8	1996
Geothermal	+998	6.7	1998
Green Architecture and Construction Services	+19,678	6.4	1989
Renewable Energy Services	+687	6.3	2002
Electric Vehicle Technologies	+5,447	6.3	2001.5
Regulation and Compliance	+46,826	5.9	1995
Recycling and Reuse	+39,668	5.4	1993
Remediation	+15,539	4.7	1996
Air and Water Purification Technologies	+6,858	4.7	1993
Public Mass Transit	+82,601	3.9	1989
Waste-to-Energy	+754	3.7	1990
Waste Management and Treatment	+79,401	3.3	1994
HVAC and Building Control Systems	+14,946	3.3	1993
Energy-saving Building Materials	+25,985	2.5	1993
Organic Food and Farming	+15,025	1.8	1987
Nuclear Energy	+7,813	1.6	1994
Battery Technologies	+1,524	1.4	2002
Green Building Materials	+7,081	1.4	1989.5
Recycled-Content Products	+3,237	0.8	1992
Green Consumer Products	+232	0.0	1992
Sustainable Forestry Products	-4,299	-1.0	1992
Pollution Reduction	-1,038	-1.4	1992
Lighting	-1,971	-1.8	1992
Energy-saving Consumer Products	-4,405	-2.9	1993
Appliances	-9,063	-3.1	1989
Green Chemical Products	-6,173	-3.4	1992
Hydropower	-16,158	-3.6	1990
Water Efficient Products	-9,189	-7.3	1992
Training	+266	N/A*	1989
Aggregate Clean Economy	**+565,337**	**3.4**	**1995**

**The training segment had zero jobs in 2003*

Source: Brookings-Battelle Clean Economy Database

3,700 jobs. The wind power industry added 15,000 jobs, growing 14.9 percent per year. Solar PV added 12,286 jobs with 10.7 percent average annual growth. Moreover, biofuels, another renewable segment, added 9,300 jobs with 8.9 percent growth each year over the period.

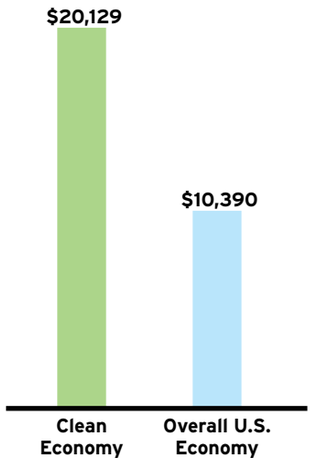
Young, technology-heavy segments were also adding jobs at elevated rates each year over the period. For example, establishments involved in fuel cell production created roughly 3,500 jobs while those working in smart grid added 7,000, with annual growth of 10.3 and 8.6 percent respectively.

The slowest growing segments, by contrast, saw job losses from establishment contractions overwhelm job gains from expansions and openings. Many of these losses took place in older building- and building infrastructure-related segments that were evidently hurt by the housing-centered recession, including, for example: water efficient products (e.g. plumbing and bathroom equipment); green chemical products (house paint); appliances; and energy-saving consumer products (office equipment, glass, home weatherization services). Hydropower and nuclear energy also experienced weak growth, with the former actually losing jobs.

3. The clean economy is manufacturing and export intensive. Manufacturing and exporting are strengths of the clean economy. Engaged in the production of everything from house paint to fuel cell components and refrigerators, approximately 26 percent of all clean economy jobs are involved in manufacturing, compared to just 9 percent of jobs in the economy as a whole.[10] In addition, Brookings estimates that in 2009 clean economy establishments exported an estimated $49.4 billion in goods, representing 5.3 percent of all U.S. goods exports. Such establishments were also responsible for an additional $4.5 billion in service exports.

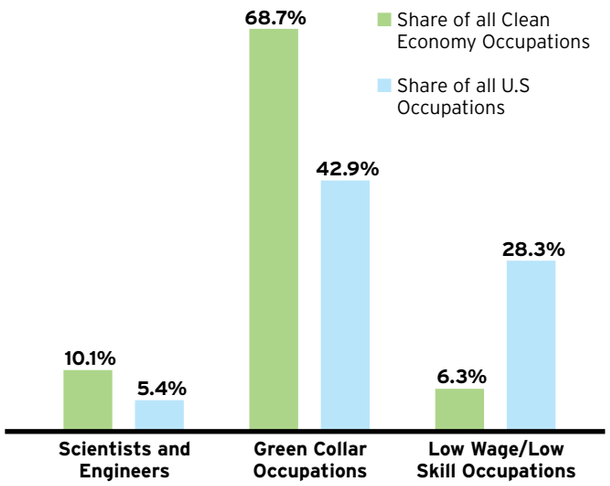
Manufacturing, for its part, accounts for a majority of the jobs in over half of the clean economy segments: 20 to be exact. Several segments—including electric vehicle technologies, water efficient products, green chemical products, appliances, sustainable forestry products, lighting, recycled-content products, and energy-saving consumer products—are particularly manufacturing intensive, with roughly 90 percent or more of their jobs residing in manufacturing establishments. Both solar-related segments, along with wind energy, have more than two-thirds of their jobs in manufacturing. Even the organic food and farming segment is largely comprised of manufacturing

Figure 3. Exports Per Job in the Clean Economy Versus the Overall U.S. Economy, 2009



Source: Brookings-Battelle Clean Economy Database; Brookings analysis of United States International Trade Commission, Bureau of Economic Analysis, and Moody's Economy.com data

Figure 4. Occupations in the Clean Economy, 2010



Source: Brookings-Battelle Clean Economy Database and U.S. Bureau of Labor Statistics Occupational Employment Statistics and Employment Projections Program

establishments involved in food processing.

Moreover, the share of all manufacturing jobs engaged in clean economy production is on the rise. From 2003 to 2010, clean manufacturers added 35,832 jobs (excluding closings), while U.S. manufacturers overall laid off 3.3 million workers.[11] Clean economy manufacturing employment expanded at a rate of 0.8 percent each year (or 5.5 percent over the entire period); meanwhile, U.S. manufacturers at large shed jobs at a rate of 1.5 percent per year (for a growth rate of -10.1 percent over the period). Again, both of these rates exclude jobs losses from establishments that closed over the period, since that data was not available for the clean economy.

Manufacturing frequently is linked to exporting, meanwhile, and so it is in clean economy. In fact, on a per job basis, the clean economy is about twice as export-oriented as the national economy. To be precise, Brookings estimates conclude that some $20,129 worth of exports is sold for every job in the clean economy, compared to just $10,390 in exports for the average U.S. job.[12] The most export-oriented segment—on an exports per job basis—is biofuels, which generates an estimated $189,000 in exports per job. This is followed by green chemicals, electric vehicle technologies, wind, battery technologies, solar PV, fuel cells, air and water purification technologies, and recycled-content products, which export roughly $63,000 per job.

These export estimates were calculated by Brookings based on the NAICS industry of each clean economy establishment. The external methods appendix document discusses the methodology in more detail.

4. The clean economy offers more opportunities and better pay for low-skilled workers than the national economy as a whole. Another strength of the clean economy is the access it affords to decent jobs up and down the skills ladder. Typical wages in the clean economy exceed those in the aggregate U.S. economy by roughly 13 percent, based on an analysis of the dataset. The median wage of a typical clean economy job approaches $44,000. This figure far exceeds the compensation level of the typical job in the United States. The national median wage is just $33,190 (or $38,616 if calculated using a weighted average of the medians, as was done for the clean economy).

This should not be interpreted to mean that clean economy firms are somehow more generous towards their workers, which may or may not be true. Indeed, previous research suggests that clean producers act like other companies in whatever industry they occupy.[13] Rather, as the methods section and external methods appendix describes, these wage statistics were estimated based on the (four-digit NAICS) industry group, which generated occupational estimates and finally wages. In other words, the better pay reflects the fact that the clean economy jobs are in better paying industries with better paying occupations.

In fact, a large majority of jobs in the clean economy are middle-wage "green collar" occupations defined here as those having a median wage that falls within 20 percentage points of the national median wage of $33,190 ($26,552 to $39,828). Of the 22 major occupational groups defined by the Bureau of Labor Statistics, the six that fall below this range are classified as low wage/low skill occupations, the seven that fall within it as middle wage/middle skill, and the nine above it as high wage/high skill occupations (see Appendix E).

As Figure 4 shows, more than two-thirds of all clean economy jobs fall within this middle-wage "green-collar" category, compared to 43 percent of jobs in the broader economy (see data appendix for details). This middle-wage clean economy orientation reflects the large number of installation and construction occupations in the sector (these are over 1.5 times more prevalent in the clean economy than in the national one) as well as its tilt toward occupations in production and transportation (which are over twice as prevalent in the clean economy). As a complement to the clean economy's middle-income occupational profile, numerous technical occupations populate the sector. Along these lines, the clean economy employs a higher percentage of scientists, architects, and engineers (10.1 percent) than the national economy (5.4 percent) and a much lower percentage of workers in the worst-paying occupations such as food preparation, sales, and healthcare support. Overall, just 6.9 percent of clean economy jobs lie in the lowest paying occupations while 28.3 of U.S. jobs fall into this tier.

There is also one more attractive feature of the clean economy opportunity structure: The clean economy not only pays well, but pays well even for those without post-secondary degrees. Almost half of all jobs in the clean economy are held by workers with a high school diploma or less, compared to only 37.2 percent of U.S. jobs. These clean economy jobs—many of which are in "green collar" occupations involved in making and moving products—provide higher wages than typical "low-skill" jobs: Approximately 28.1 percent of all occupations in the clean economy are strong-wage (paying above the U.S.

Table 3. Share of Clean Economy Jobs That Are Green Collar by Segment, 2010

Segment	Share of Jobs That Are Green Collar (%)	Share of Jobs That Require a Diploma or Less (%)
Public Mass Transit	90.3	54.4
Green Building Materials	85.3	61.1
Recycled-Content Products	85.0	58.1
Sustainable Forestry Products	83.7	60.1
Energy-saving Building Materials	81.6	58.7
Green Consumer Products	78.9	55.4
Remediation	78.7	52.9
Electric Vehicle Technologies	78.1	53.7
Appliances	77.8	54.0
Waste-to-Energy	76.6	49.4
Waste Management and Treatment	76.4	46.6
Recycling and Reuse	75.4	51.3
Wind	75.1	49.8
Geothermal	73.6	46.8
Water Efficient Products	72.9	50.2
Green Chemical Products	72.8	48.9
Lighting	71.4	49.6
Energy-saving Consumer Products	71.4	49.2
Solar Thermal	70.8	53.3
Hydropower	68.8	37.5
Air and Water Purification Technologies	67.9	47.6
Biofuels/Biomass	67.1	45.3
Solar Photovoltaic	66.7	45.0
Nuclear Energy	66.0	36.7
HVAC and Building Control Systems	65.2	45.0
Organic Food and Farming	65.1	59.5
Battery Technologies	64.0	44.9
Renewable Energy Services	63.6	40.5
Regulation and Compliance	59.1	29.0
Carbon Storage and Management	55.3	38.4
Conservation	50.6	27.1
Training	50.3	40.2
Smart Grid	48.2	33.4
Fuel Cells	46.1	33.9
Pollution Reduction	41.4	31.0
Green Architecture and Construction Services	32.9	26.0
Professional Environmental Services	26.7	20.2
Professional Energy Services	26.2	20.5
Wave/Ocean Power	23.0	19.6

Source: Brookings-Battelle Clean Economy Database and Bureau of Labor Statistics

median) and low-skill (the percentage of workers with a high school diploma or less is higher than the national average) compared to 13.3 percent in the national economy. Conversely, only 32.5 percent of clean economy jobs are weak-wage (paying below the U.S. median) and low-skill, compared to 41.4 percent nationally. Table 3 shows how green collar occupations and education requirements vary across segments.

5. Among regions, the South has the largest number of clean economy jobs though the West has the largest share relative to its population. Turning to the geography of the clean economy, it turns out that almost one-third of all clean jobs are located in the U.S. South. The West comes next with nearly one-quarter of these jobs, followed by the Midwest with 23 percent and the Northeast with 20 percent. Measured as a percentage of total employment, the West commands the largest relative share, as 2.2 percent of the region's jobs are in the clean economy. The Northeast also manages to beat the national average for its percentage of jobs in the clean economy (2.1 percent), followed by the Midwest (2.0 percent) and the South (1.8 percent).

In terms of absolute employment numbers, California clean economy establishments lead the nation by providing 318,156 jobs, well over 100,000 more jobs than in the next largest state, New York, whose establishments support 185,038 jobs. Texas (144,081) is third and four more states register six-digit employment levels. Impressively, seven southern states tally at least 50,000 jobs in the clean economy. These states include Florida, Georgia, North Carolina, Tennessee, Virginia, and South Carolina.

Turning to the relative size of each state's clean economy, half of the 10 states possessing the highest job shares in the clean economy are in the West. Alaska has the largest total share of its jobs in the clean economy (4.7 percent), the majority of which involve conservation and management of the environment given the state's massive parklands. Oregon (3.4 percent) is a big producer of organic food, as well as green building materials and sustainable forestry products; Montana contains vast public lands with park rangers and related professions but also jobs in solar PV and hydropower. Washington and Idaho also fall into the top ten. Yet much of West's advantage on clean intensity comes from its historic possession of national parklands. In terms of private activity, the West has a slightly lower share of jobs in the clean economy than the Northeast and Midwest. Alaska, Montana, and Idaho fall out of the top ten. Vermont, with a disproportionate number of jobs in organic food and farming, as well as green building materials, has the highest private-sector clean economy job share (as a percentage of total state employment) at 2.6 percent; Oregon remains second and Wisconsin moves up to fourth, with a strong showing in water efficient products, sustainable forestry products, recycled-content products, various building and appliance related segments, battery technologies, and fuel cells.

6. Most of the country's clean economy jobs and recent growth concentrate within the largest metropolitan areas. Focusing now on metropolitan geography, some 84 percent of all clean economy jobs resided in the nation's metropolitan areas in 2010; some 64 percent congregated in the largest 100 metros alone. That supermajority falls slightly short of the 66 percent share of the nation's population living in those metros but the gap is closing: Large metros' share of clean economy jobs has increased by 3.3 percentage points (from 60.5 percent) since 2003. All told, three-quarters of clean economy jobs created from 2003 to 2010 were created in large metros.

Some clean economy segments are more "metro-centric" than others, however, and this concentration has been highly correlated with job growth.

To the first point, the varying degrees of segment concentration in large metros are noteworthy. For example, the largest 100 metros contain over three-quarters of the jobs in some 13 clean economy segments that include, starting with the most concentrated: training, professional energy services, architecture and construction, renewable energy services, waste-to-energy, wind, professional environmental services, battery technologies, smart grid, solar PV, and mass transit. By contrast, eight segments have fewer than half of their jobs in the 100 largest metropolitan areas. These include farming and resource-oriented activities such as hydropower, sustainable forestry products, and biofuels.

Turning to the association of metro concentration with growth, the story is even more striking. Looking at the years 2003 to 2010, the segments that started the period as more concentrated in metros grew significantly faster—roughly 1.7 percentage points faster annually for every 10 percentage point increase in the share of jobs in large metros. None of the five slowest-growing segments over the period—water efficient products, hydropower, green chemicals, appliances, and energy-saving consumer products—were disproportionately concentrated in large metros in 2003. By

Table 4. Metro Areas with the Most Clean Economy Jobs, 100 Largest Metros, 2010

Metro Area	Clean Economy Jobs	Clean Share of All Jobs (%)
New York-Northern New Jersey-Long Island, NY-NJ-PA	152,034	1.8
Los Angeles-Long Beach-Santa Ana, CA	89,592	1.7
Chicago-Joliet-Naperville, IL-IN-WI	79,388	1.8
Washington-Arlington-Alexandria, DC-VA-MD-WV	70,828	2.3
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	54,325	2.0
San Francisco-Oakland-Fremont, CA	51,811	2.7
Atlanta-Sandy Springs-Marietta, GA	43,060	1.9
Boston-Cambridge-Quincy, MA-NH	41,825	1.7
Houston-Sugar Land-Baytown, TX	39,986	1.6
Dallas-Fort Worth-Arlington, TX	38,562	1.3

Source: Brookings-Battelle Clean Economy Database and Moody's Analytics

A Diversified Portfolio: Atlanta's Clean Economy

Atlanta-Sandy Springs-Marietta is the most diverse metropolitan area clean economy in the nation. Its approximately 43,000 clean economy jobs are very evenly spread across the 39 segments of the clean economy. With this breadth and depth, Atlanta—the seventh largest metro clean economy in the country—is well positioned to be a major hub in a variety of clean activities.

Even with that diversity, two export-oriented segments are highly clustered—in that employees at one establishment are surrounded by a substantial number of workers at other establishments in the same segment. These segments are green architecture and construction services—with major firms like Heery International, Winter Construction, and tvsdesign; and smart grid—led by GE, USI Energy, and Ista, amongst others. Across these segments, Atlanta has 5,605 jobs spread over 26 establishments.

The region also has another 8,332 jobs from 59 establishments in six moderately clustered segments: recycled content products (Rock-Tenn, Rehrig Pacific); green building materials (Shaw Industries); water efficient products (Toto); green chemical products (Arch Chemical, Sherwin-Williams); battery technologies (Exide and Enrev); and appliances (Hill Phoenix).

This wide presence across segments has helped make Atlanta a clean economy contender. Its growth performance has been solid—21st out of the 100 largest metros from 2003 to 2010. But more importantly perhaps, the median age of its establishments is just 12 years, making the Atlanta clean economy the sixth-youngest in the nation, among the 100 largest metros. This entrepreneurial dynamism, along with its diversity, bodes well for its future.

Source: Brookings-Battelle Clean Economy Database

contrast, of the five fastest-growing segments from 2003 to 2010, only the tiny carbon storage and management segment (which employs technologies like carbon capture and sequestration) started off the period with fewer than 70 percent of its jobs in one of the 100 largest metropolitan areas.

The connection between fast growth and metro concentration is not surprising, meanwhile. As discussed in Chapter II, large metros disproportionately claim many of the assets and resources companies need to succeed, such as educated workers, infrastructure, top-research universities, and venture capital financing.[14] Likewise, younger, more dynamic companies often start in large metros before moving out to less populated areas, once their production techniques are refined, to take advantage of lower costs.[15]

7. The clean economy permeates all of the nation's metropolitan areas but it manifests itself in varied configurations. In this respect, the clean economy exists in every region, in part because of the ubiquity of such basic clean economy activities as wastewater management, public transit, and environmental regulation. And yet, for all of its pervasiveness, the clean economy varies widely in size and shape. Most notably, because many of its companies are exporters and have adapted to varied market and policy dynamics, the clean economy is spread unevenly across U.S. metropolitan areas.

Employment levels and segment diversity

In terms of population, **New York** and **Los Angeles** are the nation's largest metropolitan areas. Accordingly, they also possess the most clean economy jobs: 152,000 and

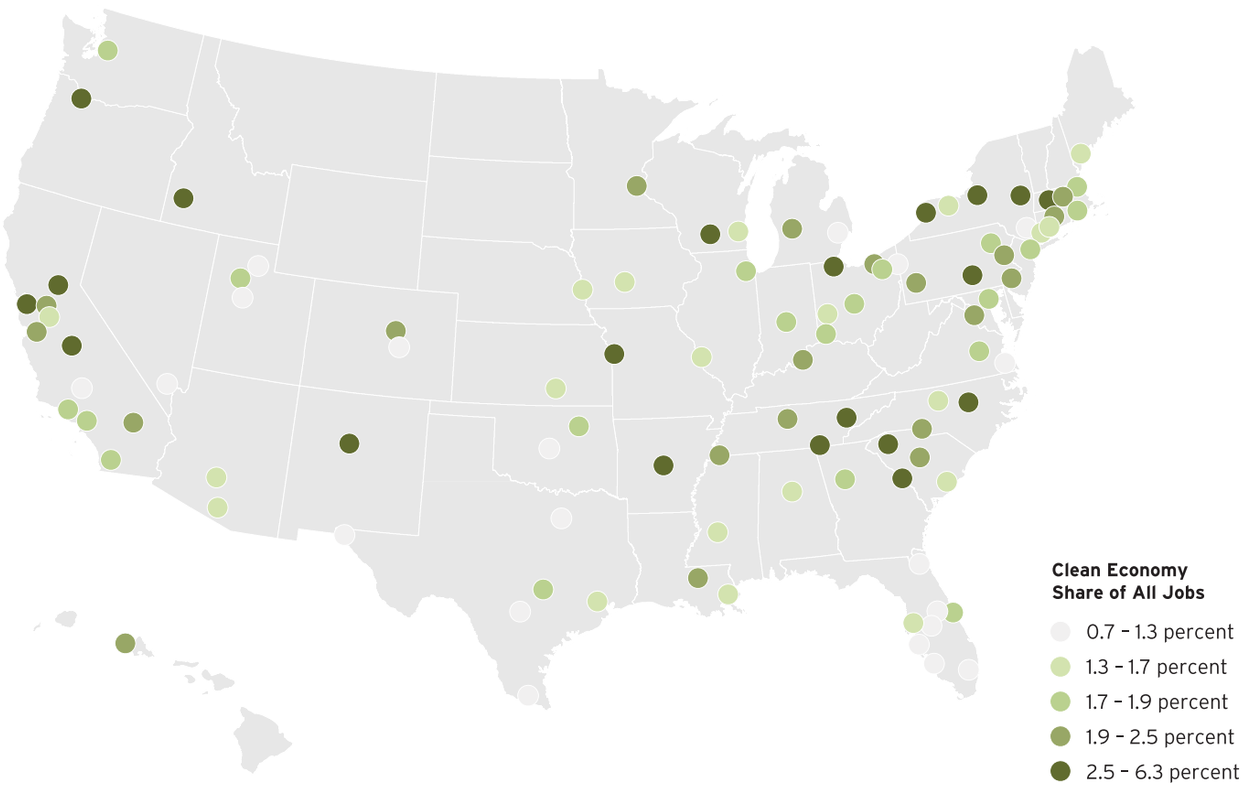
In short, the measurements and trends reviewed here offer a mixed picture of a diverse array of industry segments that is in many places making significant progress despite a very difficult economic and policy environment.

Table 5. Metro Areas with the highest share of clean economy jobs, 100 Largest Metro Areas, 2010

Metro Area	Clean Economy Jobs	Clean Share of All Jobs (%)
Albany-Schenectady-Troy, NY	28,087	6.3
Knoxville, TN	16,135	4.9
Sacramento--Arden-Arcade--Roseville, CA	37,319	4.5
Harrisburg-Carlisle, PA	13,025	4.0
Toledo, OH	11,831	3.9
Springfield, MA	10,443	3.5
Madison, WI	12,337	3.5
Little Rock-North Little Rock-Conway, AR	11,934	3.4
Greenville-Mauldin-Easley, SC	10,127	3.4
Raleigh-Cary, NC	16,677	3.3

Source: Brookings-Battelle Clean Economy Database and Moody's Analytics

Figure 5. Clean Economy Intensity in the 100 Largest Metro Areas, 2010



Source: Brookings-Battelle Clean Economy Database and Moody's Analytics

89,600, respectively. **Chicago** comes in third with 79,388. **Washington** has the fourth most clean economy jobs with 70,828, followed by **Philadelphia** and **San Francisco**, each with over 50,000. **Atlanta**, **Boston**, **Houston**, and **Dallas** round out the top 10.

These large metros have very different profiles. **New York** and **Washington** are uniquely specialized in public-goods providing segments. In the former, over 50 percent of the metro's jobs come from public mass transit and waste management and treatment. In Washington, roughly 48 percent of the jobs come from conservation and regulation and compliance activities. By contrast, in nine highly diversified metros, including **Atlanta**, **Boston**, **Dallas**, and **San Francisco**, less than 30 percent of the metros' jobs reside in the two largest segments.

Generally, large metros are extremely diversified in their segment concentrations, meaning that the share of clean economy jobs coming from each segment is relatively small. This is especially true of **Atlanta**—the most diverse clean economy with strengths in segments like smart grid, water efficient products, appliances, and architecture—but also **Milwaukee**, **Boston**, **Seattle**, and **San Francisco**. **Milwaukee** is strong in water efficient products and batteries; **Boston** establishments are disproportionately represented in such varied domains as improved coal technology, waste-to-energy, solar PV activities, pollution reduction, HVAC and building control systems, fuel cells, and professional environmental services. **Seattle's** jobs cut across renewable energy services, green architecture, smart grid, and forestry products. For its part, **San Francisco** is a center for smart grid development but specializes as well in temperature control equipment, solar PV, electric vehicles, architecture, environmental research, solar thermal, and remediation.

Assessed by their orientation to the clean economy (measured by clean jobs as a share of total jobs), many of the clean economy's regional focal points are mid-sized

Leading the Way: Albany's Clean Sweep

With a higher concentration of clean jobs than any other major metro area in the country, Albany-Schenectady-Troy, NY is a surprise leader in the clean economy.

Nearly one in 15 Albany area workers—over 28,000 people—make their living in the clean economy. Two major players stand out in driving the capital region's outsize performance: General Electric (GE) and the state government.

GE, for its part, still locates a number of critical and growing clean economy operations in its birthplace of Schenectady, including: its global renewable energy headquarters, its power and water division headquarters, and a wind and water turbine manufacturing facility. GE's advanced battery research center—the only U.S. Department of Energy-designated Energy Frontier Research Center led by a private company—completes the conglomerate's striking clean economy presence in the region.

As the capital of the third-most populous state, meanwhile, New York's "Capital District" contains another 10,500 jobs in public sector-oriented segments like regulatory and compliance and conservation too.

Yet Albany's clean economy has a richness extending beyond these two major players that hints at the emergence of a robust cluster. Over 4,000 scientists and engineers complement a concentration of over 6,000 manufacturing workers. Nearly 4,000 individuals spread across a network of 33 establishments provide professional energy and environmental services. And a solid industry presence fortified by an institutional research emphasis exists in the fuel cells segment.

Recent activity in the region's thick network of academic institutions and public-private partnerships bodes well for the region's clean economy future. The New York state Energy Research and Development Agency's (NYSERDA) energy and environmental technology energy incubator, iCLEAN, is maturing and its parent, the College of Nanoscale Science and Engineering (CSNE) at the University of Albany, has since its establishment in 2004 emerged as a global leader in semiconductor and nanotech research—technologies that drive "cleantech." For its part, the Rensselear Polytechnic Institute hosts the New York State Center for Future Energy Systems, which along with NYSERDA's activities, leverages the region's position as the state capital to establish a central node in a state-wide, cross-disciplinary, market-oriented clean economy knowledge network.

Sources: Brookings-Battelle Clean Economy Database; College of Nanoscale Science and Engineering website; General Electric Company press releases: January 21, 2011; February 1, 2010; May 19, 2009.

metros. They include six state capitals, which is largely a function of the outsized role played by the public sector in maintaining environmental health. The **Albany** region, for example, has the largest share of local jobs (6.3 percent) in the clean economy of any large metro nationwide. As both a state capital and a home to GE dating back to Thomas Edison's tenure, it has a massive presence in wind-related activities, battery technologies, professional energy services, fuel cell development and production, and regulation and compliance—its largest segment. It is also over-represented in hydropower, remediation, conservation, and environmental research among others.

Among clean economy intensive locales, Albany is followed by **Knoxville**, with 4.9 percent of its jobs in the clean economy, and then two state capital regions, **Sacramento** and **Harrisburg**, which have clean jobs that stand at 4.5 and 4.0 percent, respectively, of total jobs. With over half of its jobs coming from just one segment—professional energy services—**Knoxville** has one of the least diversified clean sectors in the nation, largely because Oak Ridge National Laboratory has such a major presence. As the seat of a large state government, **Sacramento's** clean economy is largely composed of the public conservation and regulatory sector, and yet it also has a strong presence in professional environmental services, recycling, and public mass transit. **Harrisburg** is similarly weighted towards the public sector but as home to Three Mile Island also has a large number of jobs in nuclear power.

Toledo and **Madison** represent the Midwest in the top 10 most clean-oriented major metros, while **Greenville, SC**; **Little Rock**, and **Raleigh** comprise the strong southern contingent. Toledo has the third-highest percentage of private sector jobs in the clean economy, at 3.7 percent. Solar PV is a leading segment along with fuel cells, battery technologies, regulation, green chemicals, green consumer products, solar thermal, and nuclear energy. **Greenville, SC** is similar to Albany in its strength across a number of clean technologies, including wind, electric vehicles, lighting, and water efficient products. **Little Rock** gathers a large number of jobs in green consumer products as well as electric vehicles, while **Raleigh** has a disproportionate number of jobs in training, smart grid, pollution reduction, regulation, and architecture and construction services. **Chattanooga**, finally, as another strong southern performer, has over 1,000 jobs in each of three major sectors—green building materials, nuclear energy, and hydropower—while housing a smaller but still disproportionate coterie of jobs in geothermal, battery technologies, and wind.

Employment growth

Employment growth also ranges widely. In 53 of the nation's 100 largest metros, establishments in the clean economy added jobs at a faster clip than those outside of it from 2003 to 2010.[16] Clean economy establishments in **Knoxville**, **Raleigh**, **Des Moines**, and **Little Rock** registered the fastest growth of all large metros with annual growth rates above 10 percent. Growth in **Knoxville** was fueled by the professional energy services segment and Oak Ridge National Laboratory. In **Raleigh**, job expansions were largely attributable to the government and public transit segments, with small contributions from smart grid and a few others. In **Des Moines** too, the public sector, via conservation, drove growth, along with waste management. On the other hand, green consumer products provided the bulk of job growth in **Little Rock**. For **Albany**, which had the fifth-fastest growing clean economy among large metros, gross job expansions were almost evenly shared between regulation and compliance and the region's strong wind presence.

On the opposite end, **Grand Rapids** lost clean economy jobs most quickly from 2003 to 2010. Even excluding potential job losses from closing establishments, it lost 9.1 percent of its clean economy workforce annually (a loss of nearly 50 percent over the entire period). Much of this came from thousands of layoffs in green consumer products. These devastating losses were only somewhat offset by solid job gains in the HVAC and building controls systems segment and organic farming and food processing. **San Jose**, surprisingly, considering its innovation prowess, was ranked 95th amongst large metros on job growth in the clean economy from 2003 to 2010. Massive losses—adding up to thousands of jobs in lighting and energy-saving consumer products—outweighed the substantial job gains in the wind and solar PV segments. Job losses in **New Orleans's** non-tradable segments—namely public mass transit and waste

Table 6. Metro Areas with the Fastest and Slowest Clean Economy Job Growth, 100 Largest Metros, 2003-2010

Metro Area	Clean Economy Jobs, 2003	Clean Economy Jobs, 2010	Average Annual Change, 2003-2010 (%)	Average Annual Change (Less Public Administration), 2003-2010 (%)
Knoxville, TN	6,206	16,135	14.6	14.6
Raleigh-Cary, NC	6,788	16,677	13.7	11.4
Des Moines-West Des Moines, IA	2,472	5,256	11.4	2.4
Little Rock-North Little Rock-Conway, AR	5,916	11,934	10.5	9.9
Albany-Schenectady-Troy, NY	15,557	28,087	8.8	6.0
Ogden-Clearfield, UT	1,184	2,111	8.6	6.1
McAllen-Edinburg-Mission, TX	1,243	2,203	8.5	7.2
Tulsa, OK	4,076	7,130	8.3	5.4
Toledo, OH	6,873	11,831	8.1	8.5
Albuquerque, NM	5,851	9,912	7.8	4.3
Columbia, SC	8,099	8,568	0.8	1.4
El Paso, TX	2,570	2,695	0.7	0.3
Buffalo-Niagara Falls, NY	13,952	14,452	0.5	-0.3
Milwaukee-Waukesha-West Allis, WI	13,516	13,471	0.0	-0.2
San Jose-Sunnyvale-Santa Clara, CA	19,360	18,868	-0.4	-1.0
Modesto, CA	2,974	2,688	-1.4	-2.3
New Orleans-Metairie-Kenner, LA	8,385	7,298	-2.0	1.4
Augusta-Richmond County, GA-SC	9,110	6,106	-5.6	-5.8
Palm Bay-Melbourne-Titusville, FL	6,204	3,446	-8.1	-13.5
Grand Rapids-Wyoming, MI	17,232	8,812	-9.1	-9.4

Source: Brookings-Battelle Clean Economy Database

Table 7. Metro Areas with the Highest and Lowest Exports per Job in the Clean Economy, 100 Largest Metros

Metro Area	Clean Economy Exports (millions of 2009 dollars)	Clean Economy Jobs, 2010	Exports Per Job, 2009
Greenville-Mauldin-Easley, SC	$872.4	10,127	$86,143
Little Rock-North Little Rock-Conway, AR	$686.4	11,934	$57,514
Albany-Schenectady-Troy, NY	$1,239.0	28,087	$44,114
Memphis, TN-MS-AR	$467.7	11,515	$40,621
Grand Rapids-Wyoming, MI	$349.2	8,812	$39,631
San Jose-Sunnyvale-Santa Clara, CA	$726.8	18,868	$38,521
Louisville-Jefferson County, KY-IN	$531.9	14,447	$36,817
Charleston-North Charleston-Summerville, SC	$151.2	4,369	$34,605
Cleveland-Elyria-Mentor, OH	$830.7	24,664	$33,682
Cincinnati-Middletown, OH-KY-IN	$554.3	18,525	$29,922
McAllen-Edinburg-Mission, TX	$12.7	2,203	$5,759
New Orleans-Metairie-Kenner, LA	$40.9	7,298	$5,604
Palm Bay-Melbourne-Titusville, FL	$19.2	3,446	$5,568
Honolulu, HI	$47.8	9,269	$5,161
Sacramento--Arden-Arcade--Roseville, CA	$185.7	37,319	$4,975
Virginia Beach-Norfolk-Newport News, VA-NC	$46.8	9,594	$4,883
Ogden-Clearfield, UT	$9.8	2,111	$4,657
Youngstown-Warren-Boardman, OH-PA	$13.1	2,977	$4,402
Springfield, MA	$42.6	10,443	$4,079
Colorado Springs, CO	$5.4	1,934	$2,770

Source: Brookings-Battelle Clean Economy Database and Brookings analysis of United States International Trade Commission, Bureau of Economic Analysis, and Moody's Economy.com data

management—could be attributed to decreased demand from population declines. These losses were not fully offset by gains in remediation and professional environmental services.

Exports

Turning to exports—domestically produced goods or services sold to foreign markets—the clean economy exhibits a distinctive geographic pattern. Older clean exporting establishments tend to be located outside of large metros, while newer fast-growing ones tend to be located inside them.

On the one hand, the nation's clean economy export activity occurs most intensively in locations outside the nation's 100 largest metros, which produce just 55 percent of U.S. clean exports despite containing 65 percent of the population. According to Brookings estimates, the three segments that generate the most exports by value are green chemicals, biofuels/biomass, and organic food and farming. These are all disproportionately non-metropolitan.

And yet, much of what is exported from outside of these large metros appears to be long-standing, more traditional commodities rather than new technologies—with the exception of biofuels. Approximately two-thirds of *growing* exporters, on the other hand, are located in one of the 100 largest metropolitan areas.[17] The newer exporting clean economy, therefore, is disproportionately happening in and around the nation's largest cities.

What metros export the most? With an estimated $2 billion of clean economy exports per year, **Chicago** is the nation's largest metropolitan exporter of clean technologies, goods, and services. The metro has seven segments that export over an estimated $100 million per year, the largest of which is energy-related professional services. Most of this segment's $500 million in annual exports are from a single large diversified company that does, among other things, energy efficient engineering research in the petro-chemicals industry. HVAC and building control systems is the second largest exporting segment in Chicago, followed by biofuels, green consumer products, air and water purification technologies, green chemicals, and organic food.

Los Angeles, **New York**, **Albany**, and **San Francisco** also contribute over $1 billion per year each to the clean export economy. **Los Angeles's** leading exports are in organic food, green building products, green consumer products, recycled-content products, and water efficient products. **New York's** exports consist largely of green consumer products, organic food, professional environmental services, and recycled-content products. In **Albany**, wind energy dominates. **San Francisco** exports clean products from a more diverse group of segments, including HVAC and buildings control systems, professional energy services, and electric vehicles.

Greenville and **Little Rock** also emerge as surprisingly strong exporters, both falling in the top 15 on total value of exports. Moreover, they are the two most export-intensive clean economies of all the large metros, based on the total value of exports per job. Roughly two-thirds of **Greenville's** clean economy exports are derived from wind turbine manufacture, but substantial contributions also come from electric vehicle technologies and building products. **Little Rock** also exports electric vehicles but derives most of its clean industry earnings from green consumer products, which grew robustly over the period. Other export-intensive metros include **Wichita**, a major exporter of biofuels; traditional manufacturing hubs like **Cleveland** and **Grand Rapids**; and logistic hubs like **Memphis**, **Louisville**, and **Cincinnati**.

Occupations

For every large metropolitan area except one (**Knoxville**), the majority of clean economy jobs reside in mid-wage "green collar" occupations, meaning those with moderate wages and moderate educational requirements in production, installation, maintenance, transportation, construction, social services, office support, or protective services. In 10 of the 100 largest metropolitan areas, moreover, these jobs represent at least three-quarters of all clean economy jobs based on Brookings estimates. Almost four out of five (78 percent) clean economy jobs fall in the green collar category in **Augusta, GA**, the nation's most "middle-job" oriented clean economy, with most of the relevant occupations lying in construction (26 percent of all occupation), and large shares in transportation (14 percent), office administration (13 percent), and production (13 percent). Other heavily green collar metros offer different configurations. Green collar jobs in **Dayton**, **Colorado Springs**, and **Salt Lake City** are heavily weighted towards transportation (26, 29, and 26 percent respectively). The largest share of **Louisville's** (37 percent) and **Chattanooga's** (27 percent) green collar jobs are in production.

Because green collar jobs are abundant within the clean economy and pay relatively well for their skill requirements, they arguably hold out the richest opportunities for low-skill workers in the clean economy. In fact, in every one of the 100 largest metros, the majority of clean economy jobs are available to workers without a college degree—and most are in mid-wage green collar occupations. **Modesto**, with a disproportionate number of jobs in organic food and farming, stands out with the highest share of jobs available to non-college graduates (82 percent). **Stockton** (81 percent) has a similar profile. **Augusta, GA** (81 percent), with high job shares in remediation and nuclear energy, is the second most non-college graduate-friendly clean economy. **Rochester** (81 percent) has a high percentage of jobs in public transportation. **Grand Rapids** and **Louisville**, by contrast, are heavily concentrated in the manufacturing segments like appliances. **Grand Rapids** also has large job shares in green consumer products and wind, while **Louisville** gets a large share from air and water purification technology.

At the other end of the spectrum, **Knoxville**, **Albany**, and **Harrisburg** offer the lowest percentages of clean economy jobs requiring less than a college degree amongst large metros (with shares of 56, 66, and 68 percent respectively). For **Harrisburg**, this is primarily due to the large public sector presence. For **Albany**, a large public sector and job concentrations in professional energy services and fuel cells raise educational and scientific skill requirements. **Knoxville**, in fact, has the highest percentage of science and engineering-related occupations amongst all large metros (34 percent). **Las Vegas**, with its many green architects is second on that measure (24 percent), while **San Francisco**—through architecture and professional services—is third (22 percent).

* * *

To put it all together, at least four rough types of regional clean economy can be discerned amid much variation and local distinctiveness. One sub-set of regional clean economies appears to be dominated by **services**—transportation, professional services, construction, administration, waste management, and remediation. These metros are more likely to have grown rapidly over the last seven years and include fast growers like Knoxville, San Diego, Hartford, Orlando, Honolulu, Las Vegas, and San Francisco. Another significant group of metropolitan clean economies appears heavily engaged in **manufacturing**. These metros had mixed growth rates—depending on the particular mix of their segments and specializations—but all export intensively and provide plentiful green collar opportunities. Among these metros reside numerous Midwestern and Southern metros such

Table 8. Metro Areas with the Largest Share of Clean Economy Jobs That Are Green Collar, 100 Largest Metros, 2010

Metro Area	Share of Clean Economy Jobs that are Green Collar (%)
Augusta-Richmond County, GA-SC	77.9
Dayton, OH	76.8
Louisville-Jefferson County, KY-IN	76.1
Chattanooga, TN-GA	75.8
Colorado Springs, CO	75.6
Rochester, NY	75.3
Salt Lake City, UT	75.3
Youngstown-Warren-Boardman, OH-PA	75.1
Stockton, CA	75.0
Cincinnati-Middletown, OH-KY-IN	74.9

Source: Brookings-Battelle Clean Economy Database and U.S. Bureau of Labor Statistics Occupational Employment Statistics and Employment Projections Program

An Emerging 'Blue' Innovation Hub: Milwaukee's Water Industry Cluster

The regional clean economy consists of much more than high-profile renewable energy or energy efficiency specializations. In metropolitan Milwaukee, the buzz surrounds water technology, as the region has recently emerged as a "blue" innovation hub with a high concentration of manufacturing and research in water efficient products, water purification technology, and waste management equipment and treatment.

In 2010, the Milwaukee metro region encompassed no fewer than 200 firms in the water industry that employed about 1,167 workers in the water efficient products segment alone--good for about 9 percent of all jobs in the U.S. in that segment, according to the Brookings-Battelle Clean Economy Database. From 2003 to 2010 the region saw a 23 percent increase in jobs in the "blue" sector with 39 percent of these jobs in companies that develop water efficient products and 13 percent in companies that produce water purification technologies. These companies develop a wide range of technologies that include equipment to measure and control the flow of water, emergency water supply, and drinking and waste water treatment equipment. Companies in the water efficient products and water purification technologies segments have on average about six establishments each in the metro region and have been producing groundbreaking building products to conserve water and energy that will help builders achieve LEED building certification.

Meanwhile, the cluster is gaining strength. Companies from outside the region are beginning to recognize the significance of Milwaukee's water innovation hub by moving to join it. American Micro Detection Systems, Inc., a California-based sensor technology manufacturer, located its first major operations in Milwaukee in July 2010 and Badger Meter relocated about 25 engineering professionals from its Oklahoma facility to Milwaukee in 2010. And for their part business and academic leaders in Milwaukee teamed up in 2009 to develop the Milwaukee Water Council to leverage the metro region's resources into an innovation cluster that can turn the next wave of water technologies into successful companies that have the potential for serious growth.

Sources: Brookings-Battelle Clean Economy Database; Dean Amhaus, Executive Director, Milwaukee Water Council, telephone interview, May 17, 2011; Milwaukee Water Council, "Overview of Milwaukee's World Water Hub;" "Milwaukee lands federal grant to develop water cluster," BizTimes.com, September 3, 2009; Milwaukee Water Council, "Executive Briefing," April 4, 2011.

as Grand Rapids, Greenville, Louisville, Memphis, Little Rock, and Cleveland, but also San Jose out West. On the other hand, the **public sector** supplies roughly half of clean economy jobs in state capital metros like Harrisburg, Sacramento, Raleigh, and Des Moines, helping these areas score highly on clean job intensity. Finally, a significant number of diverse metros exhibit fairly **balanced** profiles across the major industry groupings. This array of multi-dimensional clean economy centers includes Atlanta; Stockton; Portland, OR; Providence; Salt Lake; Detroit; and Los Angeles. In short, the clean economy pervades all of the nation's metropolitan areas but it manifests itself in many different configurations.

8. Strong industry clusters boost metros' growth performance in the clean economy. A final finding pertains to the role in economies of industry clustering—geographic concentrations of interconnected firms often accompanied by supporting or coordinating organizations. In this connection, it turns out that establishments in the clean economy add jobs markedly faster when they are located near peer establishments in the same county and same segment. To be precise, doubling the size of a clean economy cluster—the number of same-segment jobs in a county—increased job growth of establishments in the cluster by roughly 2.1 percent from 2003 to 2010, holding all else equal in a model tested here and discussed in the external methodological appendix.[18] In 2003, for example, jobs in clustered establishments represented 16.6 percent of all clean economy jobs. By 2010, that share increased to 19.0 percent.[19] These findings are consistent with volumes of academic work showing that clusters benefit economic performance in a variety of industries.[20]

The benefits of peer proximity are reinforced and magnified in large metros. The average clean economy establishment in a large metropolitan area is located in the same county as 1,130 other jobs in the same segment. By contrast, the county level of exposure to same-segment jobs was just 190 for clean economy establishments outside of the 100 largest metros. That difference in peer proximity is worth 5.5 percent higher job growth annually over the seven-year period ending in 2010, holding all else equal.[21] In this respect the clean economy is like most industries where new, fast-growing firms disproportionately emerge from large metro agglomerations.[22]

The findings above use a "continuous" definition of clusters based on the size of other establishments in the same segment. However, an alternative "binary" definition can be employed to compare clustered to isolated establishments. For these purposes, an establishment had to be located in the same county as at least 1 percent of national jobs in its segment to be considered clustered.

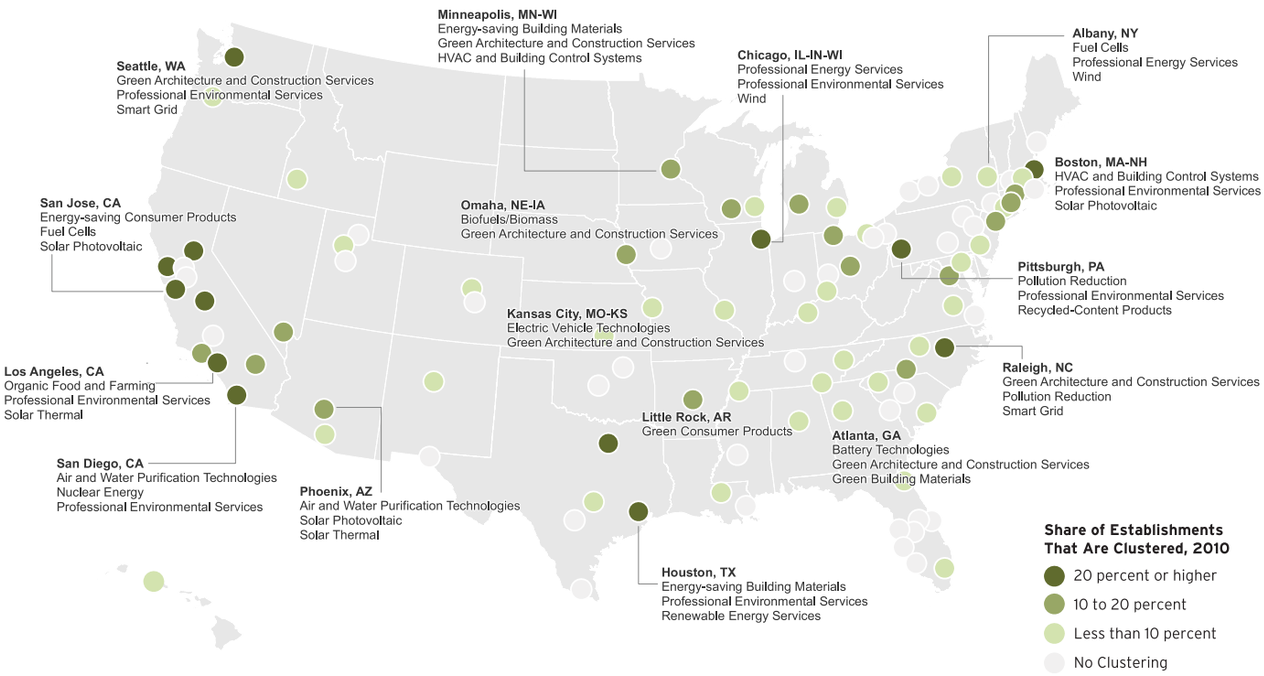
Other definitions were used, which obtained similar results, but the 1 percent definition proved to be the strongest predictor of job growth. With this definition, clustered establishments grew at a rate of 4.6 percent annually from 2003 to 2010, while isolated establishments grew at a rate of just 3.2 percent.[23] This definition gives larger counties an advantage but that advantage appears to be justified: As discussed in the external methods appendix, the benefits from clustering are robust to controls for county-size.

At the metropolitan level, the analysis was restricted to establishments in the tradable or export-oriented segments of the clean economy. This excluded all nine segments that export less than $4,000 per worker on average.[24]

In 13 of the largest 100 metropolitan areas, at least 20 percent of clean economy establishments are embedded in clusters—as defined above as proximity to at least one percent of U.S. jobs in an export-oriented segment. By that standard, **Houston** provides a clustered environment for 74 percent of its clean economy establishments—the highest percentage for the nation's 100 largest metropolitan areas. In fact, in nine of its segments, at least 75 percent of the establishments are clustered. These segments are: renewable energy services, geothermal, green architecture and construction services, professional energy services, energy-saving building materials, wind, professional environmental services, HVAC and building control systems, and biofuels/biomass. They range from as few as two establishments (in the small segment geothermal) to 123 (in professional environmental services).

Clean establishments in metropolitan **Los Angeles** are also exceptionally clustered, with 73 percent of establishments meeting the cutoff. Here, six segments are completely clustered: energy-saving consumer products, solar PV, pollution reduction, organic food and farming, green architecture and construction services, and professional environmental services. Another eight segments in Los Angeles cluster at least 75 percent of

Figure 6. Metro Area Establishment Clustering, 2010



Source: Brookings-Battelle Clean Economy Database
An establishment in a given segment is defined to be in a cluster if other establishments in the same county comprised at least one percent of all U.S. employment for the given segment.

establishments. **Seattle** is high on the list with 45 percent clustering, through professional energy services, green architecture and construction, professional environmental services, organic food and farming, sustainable forestry products, wind, and smart grid. Metropolitan **Pittsburgh**—with a clustering rate of 36 percent—has highly clustered segments such as professional environmental services, wind, pollution reduction, and solar thermal. The **Boston** metropolitan area clusters roughly 30 percent of its establishments in segments like fuel cells, green architecture and construction, solar PV, professional energy services, and energy-saving consumer products. By contrast, **Little Rock's** green consumer product makers are highly clustered while no other segment is.

Under this strict 1 percent definition of clusters, 37 large metropolitan areas completely lack clustered establishments. Many of these have location quotients above one for various segments—indicating a disproportionate number of jobs in the segment relative to the United States—but these jobs largely come from a single large establishment or are spread out in different counties within the metro. The metros have proven that they have the workforce, infrastructure, or business climate to sustain successful clean economy companies and yet they haven't been able to fully generate the benefits of a densely clustered network of similar firms in any one segment.

* * *

In short, the measurements and trends reviewed here offer a mixed picture of a diverse array of industry segments that is in many places making significant progress despite a very difficult economic and policy environment.

On the positive side, the data depict a modest-sized but widely distributed set of industries that already employ more people than the fossil fuels and biotech industries and which is already nearly half the size of the nation's formidable IT industry.

Measured aggregate growth created nearly half a million new jobs in the years between 2003 and 2010 and some "hot" segments—high-flying renewable energy categories like wind energy and solar PV—doubled and tripled in size (albeit from small bases).

What is more, the data make clear that the clean economy is producing an array of positions useful to the nation's need to renew its economic base. Clean economy jobs are inordinately oriented toward manufacturing and exporting. Likewise, they offer an attractively balanced array of jobs and occupations, with substantially more opportunities and better pay for lower-skilled workers along with many positions in fast-growing "innovation" fields.

And yet, it must be said that the clean economy remains at present more an aspiration than a large center of present-day employment. A fraction of the size of the health industry, the U.S. clean economy remains small where it is fast-growing and relatively slow-growing on balance, as defined here. Moreover, the green economy encompasses—along with its newer, smaller, expanding private-sector firms—significant numbers of mature or public sector establishments that will not likely yield substantial growth in the future.

Overall, then, the clean economy in the U.S. and its regions should be deemed a diverse, multi-layered complex of both established and innovative pursuits, the older of which are important but sometimes mundane while the newer ones are frequently dynamic, emergent, and potentially transformative.

V

ADVANCING THE CLEAN ECONOMY

Fueled by innovation and private-sector entrepreneurship, numerous clean economy industries—particularly in the cleantech space—have emerged from the recent financial crisis and are progressing rapidly along relevant technology, cost, and employment measures.[1]

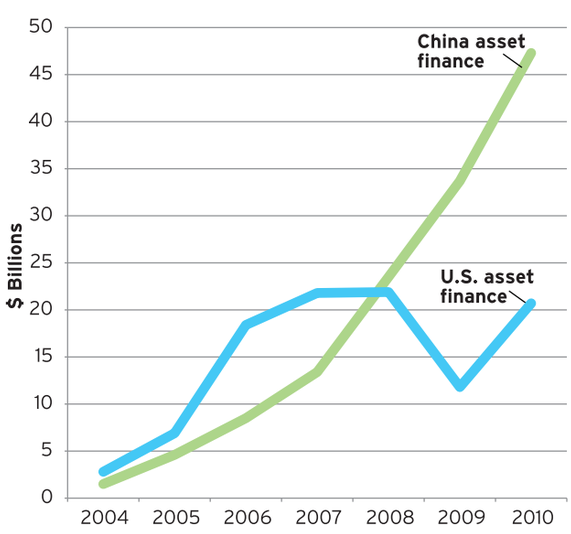
As a result, near double-digit annual growth in key segments and in key regions really does point to the possibility of the clean economy generating significant numbers of jobs in a variety of emerging global industries, whether it be cutting-edge renewable energy solutions and improved energy efficient building systems or integrated systems for water purification and environmental remediation.

And yet, notwithstanding the lack of comparable cross-national data in this report, serious questions surround the relative size and growth rate of the clean economy in the United States compared to in other countries.

Bloomberg data on the renewable energy sector depict a massive, growing shortfall between U.S. and Chinese asset financings—that of hard infrastructure like solar arrays, wind farms, or cellulosic ethanol refineries, which represent the most tangible form of industry scale-up.[2]

Likewise, while the nation still runs an overall trade surplus in environmental technologies on the "green" and "blue" side of the clean equation, U.S. firms are losing market share both at home and abroad to competitors from other nations.[3]

Figure 1. U.S. and China Clean Energy Asset Finance



Source: Bloomberg New Energy Finance

All of which raises the question of what governments and regional leaders should do—if anything—to catalyze faster, broader growth across the U.S. clean economy.

To be sure, the private-sector—influenced by local and world technology and market dynamics—will play the lead role in driving growth.

Much as they did in past waves of economic change, private initiative and private capital will do the lion's share of the work of turning ideas into business concepts and business plans into large-scale market breakthroughs.

In that sense, private-sector firms can and will step up with their own responses to environmental, security, and economic opportunity, whether by greening their ongoing business processes as Wal-Mart has because it reduces costs and appeals to customers, or moving as Google has done to build critical infrastructure with its plan to help construct a $5 billion underwater transmission line for future wind farms off the Atlantic coast, or collaborating to promote urban sustainability as a consortium of Charlotte businesses has with its Envision: Charlotte effort.[4] Private decisions, in this regard, will ultimately determine the size and impact of the clean economy in America and its regions.

However, the success of the private sector in delivering the clean economy will also depend on the existence of well-structured markets, a favorable investment climate, and a rich stock of cutting-edge technology—all matters shaped to a varying extent by government.

In this connection, the complication of virtually every segment of the clean economy—whether it be the water and wastewater industries or the energy segments—with a profusion of fundamental market flaws and institutional problems alone argues for a government role in unleashing greater market activity.

Likewise, the fact that significant policy uncertainties are likely depressing investment in the clean economy reinforces the need for engagement and reform. After all, neither entrepreneurs and companies, nor investors will commit large sums of capital to clean economy enterprises in the absence of a predictable policy outline.

And so it is clear that before truly vibrant private-sector growth and scale-up can occur in the clean economy super-sector there must be in place a clear, supportive, and stable policy outline that:

- Fosters demand and structures a vibrant domestic market
- Ensures the availability of adequate finance
- Promotes innovation

At the same time, it is essential that supportive conditions exist that:

- Keep the focus on regions

The *regional* build-out of the clean economy matters because local markets and regional industry clusters are where the clean economy actually takes place. Regions, after all, are the prime site of the day-to-day interactions by which real companies in real places develop new technologies, start new businesses, hire workers, and grow.

To that end, this report points to three critical areas of needed engagement—as well as the need to put regions at the center of future efforts—as Americans weigh how to advance clean economy growth at a time of global challenge.

In each case private sector-led growth needs to be co-promoted through complementary engagements by all levels of the nation's federal system.

MAKE A MARKET: CATALYZE VIBRANT DOMESTIC DEMAND

A first priority for unleashing clean economy growth must be to catalyze stronger market demand for clean economy goods and services.

Vibrant domestic market is critical because strong demand—or the expectation of strong demand—in a large and growing domestic market signals opportunity, attracts investment, and induces incremental innovation.[5] Over time, the presence of strong and steady domestic demand allows firms to scale up steadily and rapidly, lower their costs, and manufacture at home. Ultimately, strong and discerning domestic demand furnishes a route to global leadership.[6] And yet, the hard fact is that the United States does not yet boast strong demand for clean economy goods and services.

The problem: Policy gaps and uncertainties are depressing domestic demand

An array of policy gaps and uncertainties currently weaken the U.S. clean economy market. Some of these problems pervade almost the entire clean economy; others apply only to narrower portions of it, such as the clean energy segments encompassing energy efficiency and renewable energy or the water industry.[7] In any event, these market policy problems pose significant challenges to scaling up the clean economy.

To begin with, the lack of a coherent carbon pricing system places clean economy goods and services in the categories of energy and resource efficiency; greenhouse gas reduction, environmental management, and recycling; and renewable energy at a serious price disadvantage—which weakens demand for almost three-quarters of the clean economy. Absent such a price signal, clean economy goods and services remain relatively more expensive than they would if the harmful externalities of coal, oil, and other fossil fuel use—which range from greenhouse gas emissions and other air pollutants, to adverse health impacts such as lung disease and infant mortality to national security costs—were factored in.[8] As a result, the incentive for both households and businesses to buy clean goods and services and for the private sector to develop them is reduced.[9]

Spotty public-sector procurement efforts are another issue—missed opportunities for governments, as early adopters, to help create the market for clean economy goods and services. Given that the federal government purchases $500 billion in goods and services annually (states and local governments spend an additional $400 billion), occupies nearly 500,000 buildings, and operates more than 600,000 vehicles, the procurement of clean energy products and services, green buildings, and environmental remediation services represents an enormous opportunity for government supply chains to create and drive the market for clean economy growth.[10] Unfortunately, public sector procurement efforts remain limited and fragmented for a variety of reasons, including inadequate information on the environmental impacts and benefits of products and services, a lack of common standards for defining "green," real and perceived cost barriers to buying green products, and market and technical uncertainties about their benefits.[11]

Inadequate access to low-cost end-user financing for energy efficient (EE) retrofits and renewable energy (RE) installations stands as another hurdle to unleashing strong market growth. Low-carbon solutions—whether for installing water-efficient products and solar panels or undertaking deep whole-home retrofits—remain inherently capital intensive, with "first cost" investment barriers having proven difficult to overcome.[12] Therefore, it is unfortunate that while a variety of policy responses have been attempted, they have remained limited in scale, whether the mechanism be direct incentives such as grants and rebates; federal and state tax credits; or such finance instruments as revolving loan funds, utility on-bill financing, energy savings performance contracting, and property assessed clean energy (PACE).[13]

Creating a Market for Renewables: Germany's Feed-in Tariff

Germany is way ahead on renewable energy deployment and a key reason is the world's most aggressive market-making strategy.

A decade ago, Germany set out to create a transparent, stable, and predictable domestic market for renewables. Most notably, the ambitious Renewable Energy Sources Act, which came into force in 2000, established a feed-in tariff program that guaranteed that electricity produced from renewable energy sources (including hydropower, wind, solar PV, concentrated solar, biomass, geothermal, and landfill or sewage gas) would receive an above-market rate of return for 20 years. The tariff is designed to cover the cost of energy production plus a profit of 5 to 7 percent, with the rates adjusted every four years to reflect technological and price developments.

The tariff, in any event, has had several effects. For one thing, it has accelerated the uptake of renewable electricity in Germany to the point that the renewable sourcing has surged from 5 percent of the electricity market in the 1990s to 17 percent today. This vibrant domestic demand unleashed by the tariff has driven the growth of a large domestic market—and export base—for clean energy, with all of the attendant economic benefits.

Investment returns on renewable energy projects have been attractive in Germany, and ensured that numerous American companies like Google, First Solar, and Good Energies have invested there. In fact, clean energy investments in Germany reached $41.2 billion in 2010, a level that surpassed U.S. investment by a wide margin. As a result, moreover, significant job creation and export prowess have followed. In 2004, the renewable energy industry employed 160,000 people but by 2009 the number had jumped to more than 300,000. Germany is now also a global leader in the production of wind and hydroelectric turbines as well as solar panels.

As to the future of the program, it seems secure, notwithstanding opposition from big utilities as their losses of market share have increased. For one thing, initiatives to drive further renewables uptake will grow even more important in Germany with its recent decision to phase out nuclear energy development. For another, the feed-in tariff's success in increasing installed capacity, growing the manufacturing industry, attracting investment, and creating jobs has made it a popular program. In that sense, economic development success has bred political consensus.

Sources: Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety website and Energy Concept Paper (September 2010); Pew Charitable Trusts, "Who's Winning the Clean Energy Race?" (2011).

Even these programs may now be threatened given current state budget shortfalls and the looming ARRA funding "cliff," by which hundreds of millions of dollars in stimulus programs for clean energy projects will soon wind down.[14]

A series of structural and regulatory barriers in the electric power and water sectors also impede the adoption of clean technology solutions. Quasi-monopolistic and heavily regulated, electric utilities heavily intermediate consumer markets and demand, and do so with a mandated bias toward the least-cost, least-risk solutions. That means that these powerful incumbents have until recently been as slow to draw in renewable sourcing as they have been to help customers save electricity (both of which would elevate the demand for clean solutions). Similarly, the slow introduction of competition and deregulation into the drinking water and wastewater sector has led to a "safe and slow" mindset and a bias towards using conventional, familiar systems and technologies rather than innovative new ones.[15]

Finally, two policy problems that directly affect market-making in the renewable energy segment are worth noting. First, the lack of a national clean or renewable energy standard—a binding law that would require that utilities acquire a percentage of their electricity from renewable and other clean energy sources, perhaps including energy efficiency—has likely depressed demand for clean solutions. Even though the country has experimented with such standards at the state level with some success, it has not maximized their potential by developing a fully national market with the associated economies of scale that would help renewable energy technologies become cost-competitive.[16] The second problem afflicting this sector pertains to the efficient delivery of clean energy to metropolitan consumers which hinges on the existence of adequate transmission capacity to deliver the energy. Here too a welter of policy problems involving the planning, financing, siting, licensing, and building of transmission lines has contributed to delivery "bottlenecks," and rendered the current transmission line development system "close to dysfunctional."[17]

Overall, the combined effect of these policy gaps is a greatly weakened demand for clean economy goods and services and delays in the emergence of a vibrant, robust market in those products.

The strategy: Improve market access and demand

In view of these problems, a number of policy responses on the part of federal, state, and local leaders could help unleash more vibrant demand in the U.S. domestic market, essential for supporting innovation and exports.

In more expansive times, the federal government might take the lead in creating market making conditions through smart policy interventions with the states playing a collaborative and active role in reinforcing clean economy market creation. Ideally, Congress would **put a price on carbon** pollution to stimulate demand for clean products and raise revenue for needed RD&D investments. Or it might **pass a national clean energy standard (CES)** that creates a "floor" rather than a "ceiling" for state standards and insists on substantial renewable energy use to bring consistent, large-scale demand to clean electricity markets.[18] Or for that matter, Washington could **establish a series of clean economy "Races to the Top"** to spur states, utility commissions, and regions to develop and execute bold clean energy deployment plans or to accelerate the deployment and uptake of new and cleaner generation technologies.[19] (For a particularly bold national effort at market-making, see the sidebar on Germany's use of feed-in tariffs).

Unfortunately, however, such moves do not appear forthcoming in Washington. And yet, if "game-changing" major steps are not likely, progress actually seems possible on other important fronts in market-making.

At the federal level, **redoubled efforts to employ government procurement**—especially leveraging and reorienting the Department of Defense's vast purchasing power toward cleaner energy sources—as a source of stable demand appear possible via executive order and congressional action.[20] Similarly, **progress on appliance and equipment energy efficiency standards** ought to be possible in Congress and would save consumers money even as they ensured a strong domestic market for energy and water efficient products and services. And for that matter the Federal Energy Regulatory Commission (FERC) might well manage to institute regulatory adjustments to **ensure more rational cost recovery** on new transmission links needed to deliver renewable and other energy to urban load centers.[21]

States, on their part, can continue to play a critical role in inducing demand for clean economy goods and services. In this respect states have long led the nation in catalyzing market demand for clean goods and services. They have addressed this in multiple ways, ranging from their multi-state experiments with carbon pricing and their frequent RPS statutes to their energy efficient building codes and renewable fuel standards to their innumerable rebate and incentive programs, tax credits, and other programs aimed at reducing end-user costs.[22] Nonetheless, tremendous opportunities exist for states to accelerate their involvement in the market-making front.

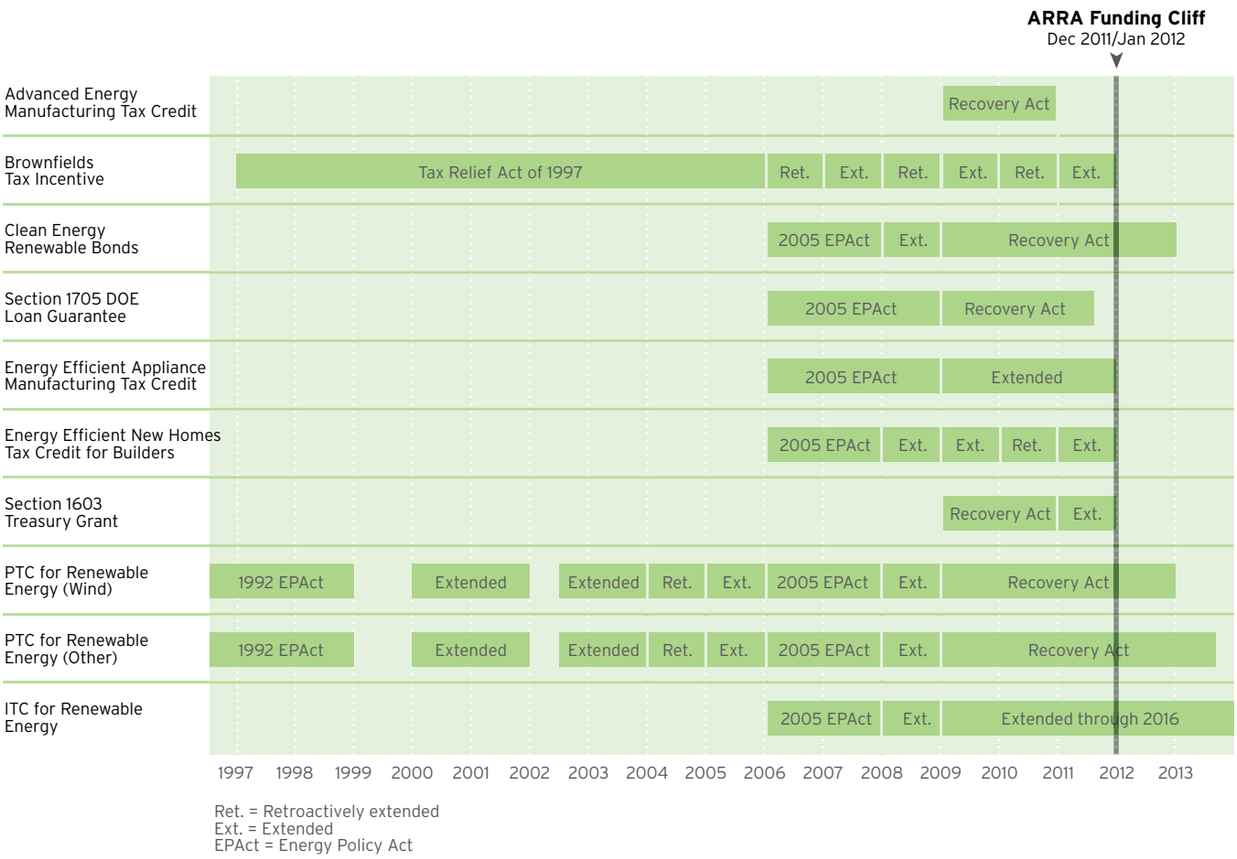
To start with, states should build on their past leadership. Whether or not a national CES becomes a reality, states can increase the demand for clean electricity by **strengthening or adopting state-level clean energy standards.** These standards have worked well in increasing clean energy deployment and boosting local economies.[23] Therefore, states that have established CES or RPS rules should consider ratcheting up their targets for utilities while the 15 states that lack a target should consider implementing one.[24]

Similarly, states should **step up their own procurement efforts**, through which they can at once drive significant local demand for green and clean products and services even as they achieve cost savings across their facilities, operations, and fleets. One way to do this would be by establishing a comprehensive framework to underpin state-wide procurement policy, which would allow both for scaling up preexisting efforts and achieving economies of scale across programs while generating more demand for clean, green, and new sourcing.[25] And for that matter states should further drive demand by continuing to work on **reducing the initial costs of EE and RE investments** for residential, commercial, industrial, and institutional customers. This has been an important past role of the states, which should now innovate again as they design and implement a new generation of creative financing mechanisms that overcome first cost barriers, leverage private with public capital, and create financial products adapted to each distinct target sector.[26]

Finally, **electricity market reform** represents a significant market-making opportunity for states. Here too states can institute a range of reforms from developing regulatory structures to promote utility investment in clean energy programs (e.g., through program cost recovery, revenue stability, and performance-based incentives) to establishing uniform interconnection requirements for connecting distributed generation applications to the grid. More fundamentally, states should consider moving to the more transparent, competitive, and flexible model in which independent system operators (ISOs) or FERC-approved regional transmission organizations (RTOs) administer the planning of new infrastructure and the pricing of wholesale electricity. In addition to its role in lowering prices, the ISO / RTO model is more conducive to clean energy because the market shares generation and transmission over a larger geographic area and harbors fewer conflicts of interest in expanding capacity to accommodate new renewable generators or in allocating costs to market participants.[27]

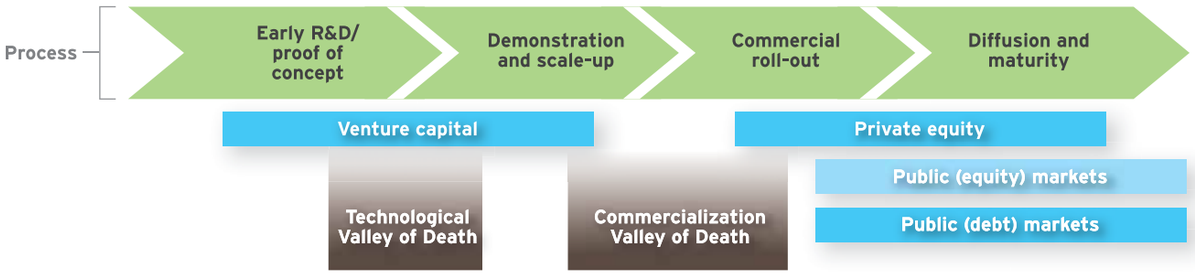
Yet those are only federal and state engagements. Local governments and regional actors across the nation can also play a role in generating more robust demand for goods and services within the clean economy sector. This they can do in a multitude of ways. Local governments can accelerate renewable energy use by buying renewable energy for public buildings, expediting permitting for projects, reusing contaminated lands—such as brownfields, landfills, and Superfund sites—for renewable energy projects, and adopting financing tools such as PACE and power purchase agreements.[28] Local governments can also **adopt green building policies and ordinances** for new buildings while creating retrofit programs for existing buildings.[29] And for that matter, local governments can **improve the fuel efficiency of fleets** servicing their community which will drive the demand for clean vehicles and clean fuels from the bottom up. Local governments can also **step up to the challenges posed by climate change** by setting targets and drafting climate action plans to reduce greenhouse gas emissions.[30]

Figure 2. Many federal clean economy tax and related incentives expire in the next few years



Ret. = Retroactively extended
Ext. = Extended
EPAct = Energy Policy Act

Figure 3. Multiple finance gaps complicate the scale-up of clean technologies



Source: Bloomberg New Energy Finance

ENSURE ADEQUATE FINANCE: ADDRESS THE COMMERCIALIZATION GAP

Market-making policies won't be enough, however. A second priority must be to address the serious finance problems that surround clean economy scale-up.

On this front, the availability of affordable capital of the right scale and with the right tolerance for risk is essential to all companies. Access to affordable finance matters inordinately in the clean economy because promising clean enterprises—whether in renewable energy or energy efficiency or water technology or air purification—often draw together intriguing but new technology, unusually heavy up-front capital requirements, and tricky regulatory or market settings.[31] Yet here again, the nation's current patchwork of responses to clean economy finance needs—especially in the energy field—remains sub-optimal and requires attention.

The problem: Responses to the deployment finance gap remain inadequate

On this front, the entire development chain through which clean economy goods and services are invented, proven, deployed, and scaled-up commercially is beset with finance challenges—challenges that have been thrown into relief by the massive recent clean energy investments of state-owned Chinese banks.[32] And yet, while significant attention over the years has focused on earlier-stage R&D and proof-of-concept challenges (the technology creation "Valley of Death"), larger finance problems located at the later-stage demonstration and deployment stage of the growth pathway now cry out the most for response—and yet remain unresolved.

The core issue is that a truly gargantuan "commercialization (or deployment) Valley of Death" now exists between the earlier R&D / technology proving stage and full-scale commercial roll-out, whether in energy or in other areas.[33]

At the earlier stage, government research dollars and VC capital are still managing to generate good ideas and provide entrepreneurial start-up companies with investments ranging from a few million to $20 million. At the very latest stages, traditional project finance and bank lending (ranging from perhaps $100 million to billions) is available for building out large, asset-based installations applying proven technology—whether it be a utility-scale solar array or a 50 million gallon cellulosic ethanol plant. However, in the intervening chasm—between the initial proof of concept that a VC can fund and the full-scale commercial roll-out typically financed by banks—few sources of capital exist for building critical initial pilot plants or scaling up advanced manufacturing facilities.

For which reason, a number of federal and to a lesser extent state initiatives have been set up to address the investment challenges of the commercialization Valley of Death—most notably the DOE's Loan Guarantee Program as well as a variety of federal and, in some cases, state tax credits. Unfortunately, though, multiple problems weaken the ability of these programs to draw private money into deployment and clean economy build-out.

The Loan Guarantee Program—which backs private loans to promising companies with new technologies—has been criticized as too slow-moving, too much engaged in "picking winners," as well as too conservative.[34] On the latter point, industry leaders, innovators, and analysts say that the program's requirements remain so stringent and prudent that they effectively replicate private-sector risk aversion—the problem the program is meant to address.[35]

As to the tax credits, these remain unstable—and are diminishing. Investors and deals require certainty, or at least predictability, about the terms and timeframe of the investment. However, U.S. deployment finance policy on the clean economy has been neither certain nor predictable (See Figure 2).[36] Cases in point are the federal Production Tax Credit (PTC) and the Investment Tax Credit (ITC) which have been allowed to lapse before being granted short-term extensions multiple times.[37] In fact, this unstable, on-again, off-again instability has affected multiple other important finance programs such as the EPA's Brownfields Tax Incentive.

Yet now things are poised to get worse. Most notably, the wind-down of ARRA's multiple provisions combined with other "sunsettings" of multiple tax code programs promises not just more "starts-and-stops" but a lot of "stops." A review of coming changes confirms, for example, that multiple clean economy-related tax provisions will expire by the end of 2011, including the Brownfields Tax Incentive, the Energy-Efficient Appliance Manufacturing Tax Credit, the Energy-Efficient New Homes Tax Credit for Home Builders, the Section 1603 Treasury Grant, and the Section 1705 Loan Guarantee Program. Other clean economy incentives such as the PTC for wind energy projects and the Clean Renewable Energy Bonds (CREB) program are set to expire by the end of 2012 (PTC for other qualifying projects end in December 2013).

In short, the whole rickety structure of the nation's main federal responses to the finance challenges faced by the clean economy faces a moment of reckoning—this at a time when the states' own engagements in clean economy finance also face resource shortfalls and rarely have the resources to address firms' later-stage need for large amounts of capital to support commercial-scale deployment.

The strategy: Address key finance gaps

Given these challenges, effective mechanisms need to be designed at all levels of the American system to draw in private capital and ensure the availability of adequate finance for clean economy scale-up.

To this end, the single most catalytic action that could be taken to advance the scale-up of new clean economy manufacturing and infrastructure could well be focused action by Congress to **create an emerging**

Ensuring Finance: China's Clean Economy Investment Strategy

China now leads the world in clean economy deployment. By the end of 2010 its 103 gigawatts of installed renewable energy generation capacity was more than double that of U.S. installations.

What explains China's success in rapid clean economy build out?

A huge part of the answer has to do with China's ability to channel vast sums of affordable capital into innovative large-scale deployment projects—something that the U.S. continues to struggle with. The numbers speak for themselves. In 2010, China put into place a staggering $54.4 billion in clean energy investments. Of this, asset financing—funding for hard assets like wind farms and solar arrays—accounted for more than $47 billion of the total. By contrast, U.S. private investment in clean energy totaled $34 billion, with just $21 billion or so in asset finance. Now the gap is widening further, with Chinese asset finance investment in Q1 2011 clocking in $10.9 billion as compared to just $2 billion in the United States.

What is China's secret in ensuring deployment finance? China has been inordinately successful in mobilizing large volumes of low-cost capital through its state-owned banks and other financial institutions. Clean energy projects have received preferential access to bank loans at interest rates far below what is available in other countries. Moreover, state-owned enterprises, especially the "Big Five" power companies, have been major investors across a broad range of energy conservation, pollution control, and renewable energy projects. For instance, China Guodian Corporation—one of the Big Five—recently announced a plan to invest $3 billion over the next five years in a variety of clean energy projects, including thermal, wind, natural gas, and biomass power stations in southwest China.

But that is only part of the story. Critical to China's success is its articulation of a comprehensive and long-term state clean energy build out policy that sends clear signals to investors. Through its 12th Five Year Plan, China has identified "new energy" as one among seven "strategic emerging industries" and will invest $760 billion over the next 10 years in this sector alone. A range of complementary policies will guide these investment decisions, including the Renewable Energy Law, national demand-side management regulations, and pilot carbon taxes, among others. China has swiftly made itself a clean energy power, in large part by ensuring the availability of copious, affordable capital at a time it has been short in the United States.

Sources: Bloomberg New Energy Finance; Pew Charitable Trusts, "Who's Winning the Clean Energy Race?" (2011); The Climate Group, "Delivering Low-Carbon Growth: A Guide to China's 12th Five Year Plan" (London: HSBC, 2011); written testimony by Julian Wong, Center for American Progress Action Fund, before the U.S.-China Economic and Security Review Commission (July 2010)

technology deployment finance entity to address the commercialization Valley of Death. (For China's aggressive parallel actions see sidebar).

To be sure, debates persist about the exact design of such a new entity. However, several sound models appear promising, including the proposed Clean Energy Deployment Administration (CEDA), which would provide loans, loan guarantees, and other credit enhancements to facilitate less expensive lending in the private sector; and the so-called Energy Independence Trust (EIT) concept developed by the Coalition for Green Capital, which would also expand access to low-cost financing to increase investment and lower the cost of deployment. Still other concepts being explored by the Coalition for Green Capital and the New England Clean Energy Council would channel stranded off-shore capital into U.S. clean economy scale-up through a qualified tax cut.[38] Either way the political moment—concerned about large scale deployment in China; frustrated with the DOE loan guarantee program—appears surprisingly favorable for what would actually be a cost-effective initiative with large returns. CEDA requires a $10 billion appropriation to catalyze a self-sustaining flow of private-sector finance for innovative deployment projects. The EIT, aimed at commercial-scale deployment of more mature technologies, would be authorized to borrow from the Treasury and repay the loans and so would require no appropriation. In both cases, any up-front costs could be paid off from a share of the revenue stream—making the programs virtually costless to taxpayers. For their part, the capital repatriation schemes would cost next to nothing. And yet, while the cost would be minimal, these mechansims' role in "de-risking" and helping finance large projects and so deploying game-changing technologies at scale could be no less catalytic than the Export-Import Bank's role in reducing the risk faced by exporters who contract with foreign buyers, or the Federal Crop Insurance Corporation's role in promoting investment in agriculture. Such institutions offer usable precedents for new clean economy finance mechanisms.

Also helpful on the finance front would be a push to **rationalize and reform the myriad tax provisions and incentives** that currently encourage capital investments in clean energy projects. In this respect, the expiration of multiple elements of the nation's mish-mash of federal deployment finance supports in fact represents an opportunity for reform. Such reform might well pair selective extensions of key production, investment, and manufacturing tax credits as well as the Treasury grant cash-back program with staged, technology-specific phase-outs, which would at once provide new industries support, predictability, and a nudge toward innovation and cost-reduction.[39] Alternatively, such a reform drive—which could be paired with a new look at reducing or eliminating subsidies to fossil fuel industries as well—might utilize competitive tendering processes like reverse auctions to contain subsidy expenditures and maximize the returns from given outlays.[40] In any event, the expiration of so many existing incentives at once is going to force a debate in the next two years and reform along the lines noted here might appeal at once to deficit hawks, members eager to provide tax benefits to the private sector, and others focused on unleashing investment and job-creation. Such a debate in Washington—paired with a serious focus on responding to the deployment finance gap—would be an auspicious development for the clean economy.

And yet, states and even regions themselves can play a huge role in accelerating the scale-up and deployment of new clean technologies and projects—as some are. For example, state development authorities—notwithstanding their limited financial and staffing resources—might consider supplementing private lending activity by **providing guarantees and participating loans** to in-state companies with promising new technologies. To be sure, the size of the relevant deals will surely fall below the $100 million to $500 million cited as the most intractable financial Valley of Death. However, when combined with private capital and other lending, state programs can still play a significant role in catalyzing the commercialization and deployment of clean technologies. Connecticut and California provide good examples of how this is being done.[41] The Connecticut Development Authority (CDA) provides up to $5 million in guarantees or supplemental financing for companies seeking to expand the production of promising new technologies. The CDA also leverages and

partially guarantees loans to clean economy companies by partnering with the U.S. DOE's Loan Guarantee Program through the Financial Institution Partnership Program (FIPP). Likewise, the California Energy Commission administers an Alternative and Renewable Fuel and Vehicle Technology Program, which authorizes loan guarantees and other financial measures out of an annual pool of approximately $100 million.

And states could go farther: In a related way, they could catalyze follow-in investment by setting up and **providing the initial funding for revolving loan funds** targeting clean economy projects using new or improved technologies.[42] Under this model, the state capital contribution could potentially be leveraged through the issuance of bonds to be repaid out of debt service. As repayments are made funds would be re-circulated into new loans. Such a model would be novel but not entirely different from California's Infrastructure and Economic Development Bank (I-Bank) or the revolving loan funds that many states use to support drinking and wastewater projects.

For their part, regions and localities can also help narrow the deployment gap, not so much through direct deployment finance as by reducing the costs and uncertainty of projects by expediting their physical build-out. In this respect, regional and local strategies to **manage zoning and permitting issues** or even **pre-approve sites** to facilitate new factory or project development would in their own way accelerate build-out by saving time and money.[43]

DRIVE INNOVATION: ACCELERATE TECHNOLOGY DEVELOPMENT

Recharging and renewing the U.S. innovation system is going to be critical too.[44]

Innovation (both radical and incremental) matters because too few clean technologies can yet compete with their incumbent competitors on an unsubsidized price basis—which remains the ultimate requirement if clean and green new technologies, processes, or services are to pervade the U.S. and world economy.[45]

To be sure, policies to catalyze market demand and facilitate financing will help scale up proven technologies and incremental innovations. However, a near consensus also insists on the imperative of complementing efforts to unleash demand with a strong push on technology development and deeper-going innovation.[46] Only through such a sustained technology push will society offset the serious market problems that prevent private firms from investing adequately to generate the next waves of products, processes, and business models, whether in cheap renewable energy, green materials, environmental remediation, or super-efficient water purification.

Yet, serious policy shortcomings continue to weaken the U.S. clean technology and processes innovation system and need to be addressed.

The problem: The nation's clean economy innovation system remains inadequate

Certainly, significant efforts have been made to improve the nation's innovation standing in recent years. However, these efforts remain inadequate in terms of both their scale and their format—and now appear in jeopardy.

In terms of their basic size, U.S. clean energy and environmental-sector technology development investments remain insufficient to ensure a steady stream of future incremental and radical technical advances.

On this front, a proliferation of market failures has long been recognized as arguing for a strong public investment role given that such problems discourage private firms from investing adequately in the technology development.[47] Yet even so, past Brookings reports (and many others) have documented the sub-optimal levels of recent federal innovation investments in the energy domain even as the current administration and Congress moved to improve them.[48] These recent steps forward have increased federal energy research, development, and demonstration (RD&D) investment—the sum of federal investments in energy system transformation—from just under $3.0 billion a year through much of the last decade to $4.7 billion in 2010 and to over $5.0 billion in the FY 2011 and 2012 budget requests.[49] Yet even these recently increased investment levels in energy innovation reflect a relatively low national investment intensity. To put current efforts in perspective, several analyses suggest a national expenditure of at least $15 billion to $25 billion annually would be necessary to bring the research intensity of the U.S. energy sector in line with that of other innovation-oriented sectors such as IT, biotech, or the semiconductor industry.[50] For more context, note that over the past two decades prior to the stimulus package U.S. energy R&D (which excludes demonstration) had declined steadily as a share of GDP to two-thirds of the OECD level.[51]

U.S. investments in water and environmental sciences also remain modest. For example, the EPA—far from the only federal agency to conduct environment-related R&D, but the one with the most applied and technology-focused portfolio—saw its R&D budget dwindle by a quarter to a low of $505 million in 2008 from its 2004 peak before it grew modestly to $538 million in 2010.[52] These investments amount to less than 0.01 percent of U.S. GDP—a figure just one-quarter the level registered by the rest of the OECD.[53]

And yet, even the sub-optimal investment levels detailed here now appear in jeopardy. Most notably, with the waning of federal stimulus investments and the rise of federal deficit anxiety, recent progress on improving the level of federal innovation investments of all kinds appears vulnerable. And neither will future reversals likely be offset by the increasingly active engagements on RD&D on the part of dozens of states—which, for their part, face tough choices on the use of their limited resources. Past state investments in energy R&D in particular have generated useful commercial innovations, but additional and sustained funding will be needed to create and build out innovative capacity in universities, industry, and the labor market—and it may not be available.[54]

But the problems weakening the nation's low-carbon and environmental innovation system go beyond the inadequate scale of current efforts. In addition, the format of innovation efforts also remains inadequate. Too much of the nation's past energy and environmental research has been based on an obsolete research paradigm, oriented heavily to either individual campus-based research projects or else to the highly "siloed," often insular and bureaucratic efforts of the DOE's energy laboratories.[55] On this front too, the Obama administration and Congress have in recent budget cycles responded—at least on the energy side—to calls for reforms. Most notably, the nation has begun to fund a trio of novel DOE start-up programs aimed at renovating the insular, stovepiped research approaches of the department. These include the Energy Frontier Research Centers (EFRCs), focused on multi-disciplinary scientific research on current barriers to technology progress; the Advanced Research Projects Administration-Energy (ARPA-E), focused on "high-risk, high-reward" projects in the translation stage; and the Energy Innovation Hubs, spanning the innovation and commercialization chain from invention to adoption.[56] Also laudable is the EPA's support of the Southeast Ohio-centered Water Technology Innovation Cluster (WTIC) program.[57]

Budgetary uncertainty now surrounds all of these experiments. After a stimulus infusion of $400 million for use in FY 2009 and 2010, for example, ARPA-E was allocated only $50 million in the initial FY 2011 budget proposal in H.R. 1 and ultimately received a modest $180 million in overall funding as a result of the recent budget deal struck by Congress.[58] Likewise, Congress has so far funded only three of the originally requested eight energy hubs, with funding for future years and more institutes appearing dicey.[59]

Advancing Energy Innovation and Technology: NYSERDA's Clean Energy Business Incubator Program

New York State is rapidly emerging as a leader in clean energy innovation, including through its statewide programs funding early-stage R&D, business incubators, and clean energy demonstration projects. Many of the state's efforts are being orchestrated by the New York State Energy Research and Development Agency (NYSERDA), a public benefit corporation created in 1975 by the New York State Legislature. NYSERDA's annual budget is approximately $620 million and its primary funding is derived from an assessment on the sale of electricity in New York State. NYSERDA has distinguished itself by undertaking a strong, tailored regional approach to promoting investment in emerging technologies and encouraging growth of the renewable and clean energy industry in New York state metro areas.

One way NYSERDA is fostering cleantech innovation is through promoting successful partnerships between early-stage cleantech companies and regional incubators that provide guidance, technical assistance and consultation to companies to help them develop and commercialize clean energy technologies. Since 2009, NYSERDA has invested nearly $9 million in six cleantech incubators through the Clean Energy Business Incubator program: Long Island High Technology Incubator, Inc. at Stony Brook University; Rochester Institute of Technology's Venture Creations; the University of Buffalo's Office of Science, Technology Transfer, and Economic Outreach; the Tech Garden at Syracuse; the NYC Accelerator for a Clean and Renewable Economy (ACRE); and the Incubator for Collaborating and Leveraging Energy and Nanotechnology (iCLEAN) at the University of Albany.

As of the end of 2010, with only 18 months of operation and $2.5 million in program expenditures, the Clean Energy Business Incubator program has already achieved significant results. The six incubators have nurtured the creation of several hundred net new jobs at client startup companies and the introduction of 26 new products to serve the clean energy market. They have assisted client companies in raising $16 million in private capital and attracting $11 million in federal funding, leveraging state expenditures by more than 10 to 1.

NYSERDA's efforts to help clean energy businesses develop and commercialize new energy technologies has been critical in helping New York create and retain the types of the companies that form the bedrock of a clean energy economy.

Source: NYSERDA's Clean Energy Business Incubators, available at www.nyserda.org/BusinessDevelopment/ourpartners.asp; E-mail correspondence with Janet Joseph, NYSERDA.

Fostering Regional Innovation in Northeast Ohio: NorTech's Advanced Energy Roadmaps

Northeast Ohio—home to over several hundred clean economy companies—is well positioned to emerge as a leading center for innovation in technologies related to electric vehicles, energy storage, the smart grid, and waste-to-energy processes. Now, a regional economic development organization is moving to make sure that happens.

Serving as the focal point in Northeast Ohio for the advanced energy cluster, NorTech, a regional nonprofit economic development organization, is leading the development of a series of advanced energy technology and industry cluster roadmaps. Because industry roadmaps provide strategic guidance for economic development efforts to accelerate innovation and commercial activity, they can be a dynamic tool for setting priorities, allocating resources, aligning stakeholders, and focusing efforts. Along these lines, NorTech is using its extremely collaborative roadmapping model to identify the distinctive strengths of the region, characterize the relevant global markets' drivers and opportunities, assess the competitive landscape, articulate a shared vision for the region, and outline opportunities.

To begin with—and also to differentiate itself from other regions that are trying to build energy-related industries—NorTech has identified four sectors with compelling regional assets, global market opportunities, and potential to result in significant regional economic impact in the near term. Leveraging a $300,000 grant from the federal Economic Development Administration, NorTech has crafted roadmaps for the energy storage, smart grid, fuel cells, and waste-to-energy sectors that will ultimately enable the region to claim a large chunk of the burgeoning advanced energy market. As part of the roadmapping process, NorTech is also using "cluster sourcing" as a mechanism to foster innovation within the advanced energy cluster. Through this process, NorTech organizes and facilitates innovation working groups consisting of cluster members, researchers and other manufacturers in the value chain to attack specific challenges within the cluster and to develop new products in response to market opportunities.

In this way, the effort underway by NorTech and its Northeast Ohio partners epitomizes the sort of "bottom-up," data-informed organizing that fosters regional clusters, innovation, and job growth and advances the clean economy region by region.

Source: NorTech Energy Enterprise website; e-mail correspondence with Rebecca Bagley, NorTech.

The prospects are even bleaker for as-yet-unimplemented proposals such as one to create a number of regionally based clean economy innovation consortia to better connect the research community to market players in U.S. regions.[60]

The strategy: Keep working to improve the clean economy innovation system

To stave off retrenchment, then, and ideally to maintain forward progress on innovation system enhancement, federal, state, and regional actors will all need to combine doggedness and creativity.

Clearly no massive scale-up of energy and environmental innovation investment is likely in the near term. However, it ought to be possible for Congress to **embrace incremental growth of the energy and environmental RD&D budgets** even in the context of deficit reduction. And it ought to be possible for the body to affirm the value of its recent institutional experiments and **make incremental investments in the ramp up of the Energy Frontier Research Centers, ARPA-E, and the Energy Innovation Hubs.** Congress should therefore consider measured expansion of all of these programs and others, including a tripling of the ARPA-E budget, the creation of new hubs, the creation of a **water sciences innovation center**, and the establishment of a **regional clean economy consortium initiative**.[61] For resources there is no shortage of options: Revenue to support these investments could be located through the phasing out of counter-productive energy subsidies, the "off-budget" establishment of a small surcharge on electricity sales, the implementation of a small fee on imported oil, the dedication of revenues from a very low carbon tax, or even from the repatriation of "stranded" off-shore capital.[62]

But those are federal policy options. For their part, more states may choose to engage on innovation at a moment of rising need and limited resources. Many states, after all, are highly alert to the benefits of fostering the emergence of innovative clean industries and bring to the task important local knowledge and business connections. In this connection, state RD&D activity has been an important complement to federal leadership for years, and so many states have implemented a multitude of mostly modest-scaled efforts to invest in the RD&D process at all stages, whether by investing directly in research; supporting incubators in connection with local research universities; establishing seed funds to fill the funding gap between lab research and venture funding; or supporting demonstration projects.[63] (See sidebar on New York state's ambitious approach).

In view of that, it would be a good thing for the growth of the nation's clean economy if the states found ways to **maintain or expand their effort on RD&D** notwithstanding budgetary stress. And here there is a little-known resource to draw on—the state clean energy funds that exist in more than 20 states, supported by small public-benefit surcharges on electric utility bills.[64] These funds generate about $500 million per year in dedicated revenue, most of which goes to support individual project finance and deployment. Given the needs of the moment, channeling more of those flows into critical innovation (as well as economic development) activities represents an important option for maintaining and recharging states' clean economy innovation system. Yet, states will never have sufficient funds to invest comprehensively in traditional R&D and RD&D programs, making it critical that states **focus and prioritize their innovation investments**. To do this, states should complement stepped up investment effort with a sharper focus on the precise needs of promising innovation segments in the state economy. Central to this be a rigorous embrace of detailed sector, industry, and innovation system analysis such as a number of states and regions are now pursuing. (For background on Northeast Ohio's technology roadmapping exercise see sidebar). Only by employing fine-grained data and analysis to target interventions, drive design, and track performance will states maximize the impact of scarce innovation dollars.

* * *

Clarity on each of these fronts will drive growth because it will allow actors in the clean economy to locate customers, structure finance deals, and draw on leading-edge technology in a vibrant, predictable environment.[65]

But predictability of market-making, finance, and innovation will not be sufficient. Also important will be regional strategies, which more and more entrepreneurs, financiers, economic development leaders, and policymakers believe can play a critical role in bringing it all together. This priority runs along the lines that follow:

FOCUS ON REGIONS: BUILD THE CLEAN ECONOMY CLUSTER BY CLUSTER

Regions and the regional industry clusters they contain play a critical role in growth because they foster innovation, entrepreneurship, and job creation while promoting economic efficiency.[66]

Regions are the places where—within the federalist system—research is conducted, technologies are developed, ideas are shared, and new businesses started.[67] Regions, likewise, are the places where markets are tested, deals done, projects sited, and workers and suppliers located.

In fact, the importance of regions and clusters pervades this study, one of the most important findings of which remains the fact that the number of jobs in "clustered" clean economy establishments grew significantly faster than did the number in their more isolated counterparts. In this vein, industry clustering in the clean economy and elsewhere has increasingly been recognized as providing a useful and practical framework for shaping economic policy; catalyzing "bottom-up" strategy and execution; and coordinating fragmented policy offerings. And yet, notwithstanding a modest embrace of cluster concepts in recent economic discourse, much room exists for a more concerted focus on the importance of regions in clean economy development efforts.

The problem: Clean economy development efforts have placed too little emphasis on regional and industry cluster strategies

Too often place and the fact of industry clustering—the geographic concentration of interconnected firms and supporting or coordinating organizations—are left out of national clean economy discussions.[68]

To be sure, the reality of clustering in the clean economy has begun to inform federal policymaking in recent budget cycles, building on earlier inroads at the state level. Multiple federal agencies including the Economic Development Administration (EDA), the Small Business Administration, the Department of Agriculture, the National Science Foundation, and the Department of Labor now offer competitive grant programs for the modest support of regional cluster initiatives, including "green" ones.[69] In fact, several initiatives—such as the DOE's Energy Regional Innovation Cluster (Efficient Buildings) hub as well as this year's pending i6 Green Challenge to promote clean energy innovation and job growth—explicitly adopt cluster strategies into clean economy growth initiatives.[70] Likewise, a longer-standing orientation toward cluster strategies at the state level has seen the continued and accentuated application of the paradigm to clean economy initiatives in a number of states. States like Colorado, New York, and Oregon, have all applied a strong regional and cluster focus to their clean economy development initiatives.[71]

Visualizing the Clean Economy: The Metropolitan Policy Program's Interactive Mapping Tool

Far more data underlies this study of the clean economy than can be conveyed in the pages of this report. Yet, one of the core goals of this undertaking has been to provide detailed, actionable data to national, and especially regional, actors who have mostly lacked such information on the size, shape, and nature of the clean economy in U.S. regions. To that end, the Metropolitan Policy Program at Brookings has developed an interactive web-based mapping and downloads tool designed to provide in-depth access to the Brookings-Battelle Clean Economy Database that provides the basis for the analyses in this report.

Both map- and spreadsheet-oriented, the new tool allows users to visualize, or simply download data on, the geography of the clean economy at the state and metropolitan levels with an unprecedented richness of detail. Available on the site are jobs data—totals, shares, and growth—for the aggregate clean economy, five broad clean economy categories, and 39 narrower industry segments. Among the many possibilities users of the tool can disaggregate and study clean economy segments of interest, see where particular segment specializations exist, or find out where the clean economy is fastest growing (with the important caveat that the growth figures do not incorporate job losses from establishments that closed prior to 2010). Furthermore, the tool allows users to visualize the education profile of the clean economy's workforce as well as to probe wage characteristics, export orientations, and explore typical establishment ages. In all of this, the goal is to make the vast majority of the new information as widely available as possible while providing the greatest possible flexibility to users in its output and display. To explore the online application please visit the Brookings site at: www.brookings.edu/metro/clean_economy/map.aspx

Nonetheless, the leveraging of regional industrial and innovation dynamics for clean economy growth remains an under-exploited opportunity.

At the federal level, the nation's new array of regional development and green cluster offerings remains valuable but modest in scale—and frequently oversubscribed.[72] More importantly, the nation's chief energy-sector agency—the DOE—has until recently lacked a strong economic or regional development mission and still contends with a culture of insularity and aloofness from the marketplace that derives from the security mindset of its work in nuclear weapons development.[73]

At the state level, clean economy strategies do not always apply a well-focused regional emphasis—even when they adopt cluster concepts and terminology. Along these lines, state approaches to clean economy development—while well intentioned and frequently impressive—remain at times generic or ill-defined; insufficiently grounded in top-quality data analysis; or insufficiently "bottom-up."[74]

And then, while more and more regions are mounting their own increasingly strategic, locally specific initiatives to accelerate clean economy growth, not enough are.

On the positive side, regional self-assertion has emerged as a bright spot in the United States, with dozens of regionally-based intermediaries now moving to execute sophisticated growth strategies.

However, the fact remains that too few local clean economy growth campaigns are employing truly disciplined, data-rich, analytic approaches to ascertaining local specialization and accelerating home-grown growth. As at the state level, too few regions—given the limited cross-region data that has been available—have been able to assemble adequate information to really understand their clusters' market position and growth potential. Consequently, too many regional clean economy strategies focus on overly broad categories like "renewable energy" or "energy efficiency" rather than more distinctive sub-niches and developing strategy at that level.

Probably the most visible consequences of all of this inconsistent attention to cluster dynamics and locally-specific data, meanwhile, are workforce problems. On the one hand, concern has been mounting in some quarters about shortages of qualified workers, especially in the utility sector, to meet near- and long-term demand.[75] By contrast, though, more recent news and other reports—following on the investment of some $600 million of stimulus money in "green" training programs—have described situations in which the supply of trained clean economy workers has exceeded the regional market's need for them.[76] What links these seemingly opposite labor supply problems, it turns out, are widely recognized disjunctions between U.S. regions' workforce training systems and the local clean economy. Several studies note, after all, that clean economy worker training programs have neither been sufficiently data-driven nor informed by adequate partnerships between educational and training organizations, on the one hand, and employers, on the other.[77] These reports note that the multifariousness of the clean economy and its newness in some segments add to the usual challenges of securing sufficient communication and coordination among stakeholders to link industries' demands to the supply of workers.

Along these lines, it is plain that the inconsistent availability of objective, timely data about the size and growth of regional clean economy clusters has complicated the design of smart, realistic training and economic development systems at the regional level.

The strategy: Build the clean economy "bottom up," region by region

And so a broad strategy for all parties must be to place regional growth strategies specifically near the center of efforts to advance the clean economy.

At the federal level, the growing recognition in Congress of the value of regional strategies and local innovation clusters—as evidenced by the inclusion of a new "regional innovation program" in last year's America COMPETES reauthorization—encourages hopes that Congress will **support increased investment in new regional innovation and industry cluster programs**.[78] Competitive awards like the EDA's i6 Green Challenge for the establishment or expansion of regional proof of concept centers in various green technology fields has the power to further catalyze the "bottom up" clean economy development work that has broken out in numerous regions. Scaling such offerings up would accelerate growth. Funding options, while complicated in the current budgetary environment, do exist as noted in the financing discussion.

Carving a Niche in the Clean Economy: The Puget Sound's Regional Business Plan

One region that has taken bottom-up cluster development to a rigorous new level is the Puget Sound area, which has devised a hard-edged action plan to make itself a world center for a particular sub-area of the massive energy efficiency (EE) industry.

Working through a disciplined regional "business planning" process conducted in collaboration with the Metropolitan Policy Program at Brookings and RW Ventures LLC, Seattle's move has been to employ detailed data and analysis to reveal and begin to seize on its strong positioning for exporting building systems software and technology to the world.

The market opportunity is huge. McKinsey & Company estimates that $520 billion in investment is required to fully capitalize on the U.S. economy's energy savings potential through 2020. HSBC projects that the global building efficiency market will grow to $245 billion a year by then. Within this large market, the Puget Sound has targeted the building systems niche, which is projected to grow to $14 billion globally. In this niche, as it happens, the region already enjoys significant competitive advantage, ranging from a world-class array of large and small software and IT firms (arrayed around Microsoft); a significant EE consulting and services cluster anchored by McKinstry; a world-beating international business infrastructure; and the presence of progressive utilities and numerous military bases that are serving as early adopters for technology demonstration and deployment.

And so the region has devised a catalytic, bottom-up strategy to achieve its goal of world export preeminence: the creation of the Building Energy Efficiency Testing and Integration (BETI) Center and Demonstration Network. BETI will allow EE IT innovators in the region to test, integrate, and verify promising products and services before launching them to market, providing a potentially game-changing boost. BETI would be a self-financing entity whose real-world facilities firms and entrepreneurs would pay to access and whose validation would become industry standard, establishing the region as a global EE IT hub.

BETI's ambition and grounding in rigorous market analytics are exemplary in their own right. Even more significant, however, is what the region's complete business planning effort represents: a region coming together, taking the initiative to fundamentally understand its economy, and acting intentionally on the findings. While too many other states and regions fritter away money chasing the next hot cleantech fad, the Puget Sound is assiduously carving itself a niche in the next economy.

Source: "Innovation Meets Demonstration: A Prospectus for Catalyzing Growth in the Puget Sound's Energy Efficiency Cluster" (Brookings Institution, 2011); and Puget Sound Regional Council and Prosperity Partnership, "Business Plan for BETI" (2011), available at www.psrc.org/econdev/beti.

States, for their part, need to make regions and metropolitan areas central to clean economy growth strategies. State leaders need to understand and embrace the fact that the clean economy is significantly region- and metro-led.[79] What does that mean? By and large, it means that more states should empower regional clean economy cluster initiatives. States, to begin with, should work with the federal government and their regions—as many now are—to **improve the information base about local industry clusters**, with an emphasis on pulling together objective market analysis on their size, growth, market positioning, and challenges.[80] Too little is as yet known about these industries at the crucial regional level, and that has impeded good strategymaking.

Beyond improving the data, states can also play a critical role in advancing U.S. clean economy growth by making sure their clean economy activities **firmly support regionally crafted cluster strategies**. One way states can achieve this is through the provision of dedicated, modest-scaled resources—perhaps from state energy funds—to well-designed regional cluster initiatives.[81] For example, New York state has since 2009 invested nearly $9 million in six regionally-based and -oriented cleantech incubators through its Clean Energy Business Incubator program. Yet specifically titled formal "cluster" programs are only part of the picture. Equal or more value may in fact come from swinging other, more generally relevant, programs behind the regions' cluster strategies, whether it be related market-making procurement or utility initiatives; export promotion; particular finance interventions; various R&D, tech transfer, or other innovation initiatives; or workforce training policy. Such an alignment of multiple state activities with the needs of local clean economy clusters represents a low-profile but essential element of fostering growth

All of which leads to the critical role of regional actors themselves in accelerating the emergence of a dynamic clean economy in America. At this level, the needed development work will frequently be facilitative and focused especially on analysis and coordination: identifying promising local clusters, identifying the constraints they face, and facilitating joint regional action to address them.[82]

The first step for regions must be to **use data and analysis to understand the local clean economy in detail**. Currently, very few regions have access to the kind of rigorous, fine-grained information needed to make objective assessments about the nature, prospects, and needs of their local clean economies. Such data has simply not been widely available, given the difficulties of defining the clean economy and then of collecting the relevant information across diverse industries. And yet such statistical intelligence is absolutely essential to allow regions to define the terms; sort out fact from fiction; and focus regional strategy on truly viable, distinctive, and competitive networks of firms and establishments.

The data provided in this report, its appendices, and on an accompanying project website make a start. (See sidebar on visualizing the clean economy). Using this information, regions can obtain initial guidance on the relative size of their clean economy industry segments; the numbers of establishments and firms they contain; their growth; and their strength relative to those in other regions. In that way regions can begin to assemble what they in many cases do not have now: a basic empirical platform on which to base strategic clean economy development efforts.

With such a basic platform in place, regions should move to rigorously **identify clusters' binding constraints** and then move to **formulate strong, "bottom up" action** to address them. To the first point, a top priority of regional cluster participants and intermediaries should be to tease out the specific hurdles to the further growth of an area's most extensive, concentrated clusters. In this connection, rigorously identifying the most promising clusters on which to focus development efforts is part of the work but equal effort must drill down on isolating the specific impediments to future growth.

Are there local procurement sources that have not been exploited that could drive growth? Are there regulatory impediments that are precluding the siting of critical capital

Metro 'Greenprints' in Four Metropolitan Areas: The Climate Prosperity Network

Four very different metro regions—Silicon Valley, Denver, Portland, OR, and St. Louis—are pursuing assertive, bottom-up regional development strategies to move to a carbon-free future. These metros are partners in the Climate Prosperity Network, a national coalition of regions that share a common belief that they can simultaneously expand economic opportunities and reduce greenhouse gas emissions through practical strategies involving business, government, education, and other community partners.

Established in 2009, the network fosters the development of tailored "climate prosperity" strategies within the context of a shared commitment to the use of good economic information to identify regions' clean industry specializations; an effective collaborative process that focuses diverse partners on a few major strategic priorities; and visionary leadership—particularly from the business community.

Along these lines, while each region seeks to hone its unique comparative advantages, each is employing a common analytic framework that focuses on expanding market demand for clean economy products and services, as well as building the regional base of clean economy companies. The four metro areas are pursuing common market and business development strategies—including promoting use of local products, aggregating public procurement, branding and marketing regional specializations, expanding clean economy financing, growing regional supply chains, training a skilled workforce, and promoting commercialization, innovation, and entrepreneurship. They have also published strategies ("Greenprints") and established outcome metrics to track regional progress.

And yet, notwithstanding the common analytic framework, each region's greenprint capitalizes on its unique strengths and priorities. Silicon Valley is engaged in accelerating the "third revolution" clean technologies—with focus on renewable energy—by standardizing procurement and permitting for solar projects and promoting smart grid infrastructure. Metro Denver represents an integrated economic development strategy encompassing education and marketing of green products and services, building and documenting the cleantech value chain, and leveraging and commercializing the region's R&D assets. Metro Portland is using the greenprint process as a "call to action" to aggressively move itself along the clean economy pathway by expanding project finance, commercializing green technologies, cultivating the cleantech, sustainable forestry and agriculture clusters, and developing a skilled workforce. And St. Louis' first step in the process of developing its strategy has been to conduct a Green Economic Profile study that provides detailed metrics on the region's green economy.

Source: Climate Prosperity Network website; e-mail correspondence with Andre Pettigrew, Climate Prosperity Project Inc.

investments? Do businesses in the cluster lack access to financing owing, for example, to their distance from VC networks in Boston, New York, or Silicon Valley?

Such a drill-down will require fine-grained, often qualitative but still precise local information, including proprietary company data, detailed survey information, real-time market intelligence, and other forms of first-hand insight. For that reason such work to pinpoint local clusters' binding constraints will always be an inherently regional responsibility.

Why is such work so important? Such work is important because it represents the essential basis for "bottom up" regional action to address cluster needs and seize opportunities. Such regional assertiveness is critical, meanwhile, because it represents the best available source of locally grounded, cluster-specific information, priority-setting, and implementation.

And as it happens, numerous regions are engaged in this sort of disciplined, data-informed work to develop smart, place-specific development strategies.

Industry and economic development leaders in the Puget Sound area, for example, have collaborated with the Brookings Institution and RW Ventures LLC to craft a regional "business plan" reflecting that region's specific clean economy specialties, with a view to strengthening the global positioning of the region's EE technology cluster.[83] (See sidebar on the previous page). Similarly, the Climate Prosperity Project, a non-profit focused on the clean economy, has been working with four regions—San Jose, St. Louis, Denver, and Portland, OR—to develop locally tailored, empirically based clean economy "greenprints" to guide clean economy development in those metros.[84] (For more on Climate Prosperity and on regional networking in the Sacramento region see sidebar above). And for that matter, some 15 regions are now working together to forge common cause as they develop clean energy "innovation consortium" initiatives aimed at addressing innovation pipeline gaps and accelerating regional cluster growth in areas ranging from New England and Michigan to San Diego. In these ways, U.S. regions are moving assertively to define the needed interventions, implement them, and share their learning, whether through local initiative or through the targeting and tuning of various federal and state efforts.

Regional implementation steps can, should, and do vary widely. Backed by all kinds of entities, regional actions to advance the clean economy run the gamut of market-making, finance-oriented, innovation, and cluster development activities.[85] On market-making, for example, Climate Prosperity's efforts in Silicon Valley, Denver, Portland, OR, and St. Louis focus on expanding the demand for clean economy good and services by promoting use of local products, aggregating public procurement, and branding and marketing regional specializations.[86] To address finance issues in its region, the Clean Tech Center at the Syracuse-based Tech Garden offers technical and financial assistance—by facilitating access to angel investments and venture capital—to entrepreneurs and early stage companies to foster clean technology business development.[87] In Wisconsin, meanwhile, the Milwaukee Water Council is working to catalyze water-tech innovation in a cluster that includes more than 100 scientists and 130 water technology companies.[88] And for that matter, CleanTECH San Diego in California, a non-profit membership organization, has developed a comprehensive one-stop-shop to advance the region's clean economy by helping companies coordinate with established research facilities to identify both synergies and gaps and network through an online registry of the region's growing cluster of clean technology companies.[89]

Among all these activities two more stand out. Given the prominence regional leaders retain on land use, regional and local officials have special power to **manage the zoning and permitting issues** that can determine how quickly and where key clean economy infrastructure or installations are sited within the demographic and workforce contexts of their communities.

Likewise, regional leaders' sensitivity to local population and business dynamics argues that they should lead efforts to **improve regional clean economy workforce development.** And here, too, regional cluster knowledge and the collection of detailed cluster data allow for improved outcomes. Too often in U.S. regions workforce training for

Advancing the Clean Economy in California's Capital Region: Sacramento's Clean Technology Story

Regional networking—and using it to devise a regional investment strategy—has brought new focus to the Sacramento region's efforts to become a hub for clean energy technology. Leading the way has been the Green Capital Alliance (GCA). The GCA unites public and private partners, including the regional economic development organizations, workforce development organizations, non-profits, the regional council of governments, and academic institutions, in common cause to make clean technology a defining feature of Sacramento region's economy.

GCA is working to develop an investment strategy for the clean energy sector that will become the central plan guiding the clean energy-related work of its partners. As part of that, GCA holds Clean Energy Technology (CET) Business Roundtables to assess opportunities in the cleantech industry, stay in tune with market realities, and make sure regional education and workforce training programs meet the industry's needs. The roundtables are also helping shape the high-level strategies emerging from Mayor Kevin Johnson's "Greenwise Sacramento" initiative, which aims to transform Sacramento into the greenest region in the country.

Sacramento has enjoyed considerable success of late in securing state and federal investment, which leaders credit in part to its now renowned collaborative approach and ability to articulate a clear regional vision. The region has also witnessed significant private investment, with the Bank of America playing a pivotal role in GCA's CET Business Roundtables by providing financial insight into the region's clean technology cluster expansion. The Sacramento Area Regional Technology Alliance (SARTA) has been chosen as one of the state's six Innovation Hubs (iHubs) with an emphasis on clean technologies. Meanwhile, University of California, Davis—a GCA partner and home to the nation's first university-based Energy Efficiency Center—supports the region's commercialization of clean energy through major research initiatives in lighting and cooling efficiency, clean transportation, and renewable energy.

The region's efforts are already producing significant results. The clean economy in the Sacramento-Arden-Arcade-Roseville metro area grew 59 percent from 2003 to 2010. Although much of this growth was driven by large state agencies, the presence of the electric vehicle technologies, solar thermal, and solar photovoltaic segments increased markedly and signals a building out of Sacramento's cleantech economy that is gaining momentum.

Sources: Green Capital Alliance website; Sacramento Area Commerce & Trade Organization website.

so-called "green jobs" (as well as other occupations) has proceeded on its own track, aspirational about what job placements training might yield and divorced from the latest market trends and real industry demand in local places.[90] The result has been disturbing shortages and surpluses of particular types of workers. However, the availability of improved data and more assertive cluster initiatives points to a better way—and one of the most important future roles of metropolitan and rural regions in advancing the clean economy. Along these lines, the use of fine-grained segment data and better communication in the design and management of worker training efforts should make possible a much more accurate tuning of training efforts to true private sector needs—and better connection of workers to opportunities. Proving that it can be done, some community colleges and other regional intermediary organizations have successfully linked training to cluster-specific industry needs with considerable success. For instance, the Los Angeles Trade-Technical College grounds all of its work on "green jobs" with careful research and industry engagement to inventory "real" employment opportunities and future demand.[91] Likewise, the Workforce Development Council of Seattle/King County (WDC) has gone to great lengths to aligning its workforce development efforts with private sector needs. First, the WDC convened an industry panel to explore market dynamics and employer needs in the area of green design and construction. Then the WDC partnered with the City of Seattle and other organizations to launch a new industry-led project to understand and meet employer needs in the residential and commercial building energy efficiency sectors.[92]

* * *

The takeaway is clear: While private enterprise ultimately will deliver a robust clean economy, federal, state, and local governments all have roles to play in co-producing a clear, supportive, and stable growth environment for it.

In that role, government must work to structure a vibrant domestic market, ensure the availability of finance, and keep the innovation pipeline charged. Throughout, regions and clean economy industry clusters must move to the center of development efforts.

Ultimately, by pursuing this course, the nation can and will build the domestic clean economy, firm by firm, and region by region. ●

While private enterprise ultimately will deliver a robust clean economy, **federal, state, and local governments all** have roles to play in co-producing a clear, supportive, and stable growth environment for it.

VI

CONCLUSION

The measurements and trends reviewed here offer an encouraging but also challenging assessment of the ongoing development of the clean economy in the United States and its regions.

In many respects, the analysis warrants optimism.

As the nation continues to search for new sources of high-quality growth, the present findings depict a sizable and diverse array of industry segments—in key private-sector areas—expanding rapidly at a time of sluggish national growth.

Already the aggregate clean economy employs more people than the fossil fuels and biotech industries. More importantly, a dozen or so "hot" segments—mostly dynamic renewable energy categories like wind energy, solar photovoltaic, and smart grid—doubled and tripled in size in the last decade, answering the hype that has surrounded them despite extremely difficult recent market and finance conditions.

What is more, the analysis suggests that the clean economy is producing jobs relevant to the nation's need to renew its economic base. Clean economy jobs are inordinately oriented toward manufacturing and exporting. Likewise, the segments of the clean economy encompass a balanced array of jobs and occupations, with substantially more opportunities and better pay for lower-skilled workers along with other positions in higher-end "innovation" fields. Having more clean economy jobs as the sector's younger, more innovative segments advance in technology, deployment, and market-penetration would be good for the nation.

Yet, the information here also underscores several challenges.

For one thing, the data counsel against excessive hopes for large-scale, near-term job-creation from the sector. After all, the U.S. clean economy remains small where it is fast-growing and relatively slow-growing on balance, as defined here. That means that while key clean economy growth segments appear of critical importance to America's future, their status as major employers remains a few years off.

Beyond that, what is more concerning about the future outlook is that the growth of the clean economy has almost certainly been depressed in recent years by significant policy problems and uncertainties.

America, its industries, and its regions are in many places making solid progress on clean economy development, especially at the early-stages of the technology commercialization pathway, where new ideas, business plans, and firms come into being. However, much evidence suggests that the scale-up of these ideas has not been maximized, due in part to policies that have left domestic demand weaker than it might be, financing harder to obtain, and the innovation pipeline unsecured for the future, even as too little attention is paid to the regional underpinnings of growth.

In that sense, what is most challenging here is the fundamental question raised by the dynamic growth but modest size of the most vibrant and promising segments of the clean economy.

That question is: Will the nation marshal the will to make the most of those industries?

In the end, it is a question raised frequently by these pages.

Appendix A. The U.S. Clean Economy by Category and Segment

Category/Segment	Jobs, 2003	Jobs, 2010	Annual average change in jobs, 2003-2010 (%)	Clean economy share of all U.S. jobs, 2010 (%)	Median age of establishment (in years) 2010	Exports per job, 2009	Share of jobs held by workers with a high school diploma or less, 2010 (%)	Share of jobs jobs that are green collar, 2010 (%)	Average annual wage, 2009	Share of traded sector establishments that are clustered, 2010 (%)
Agricultural and Natural Resources Conservation	**374,120**	**505,993**	**4.4**	**0.4**	**15**	**$13,239**	**39.4**	**58.5**	**$42,721**	**10.5**
Conservation	193,836	314,983	7.2	0.2	14	$466	27.1	50.6	$47,121	8.0
Organic Food and Farming	114,931	129,956	1.8	0.1	23	$29,677	59.5	65.1	$35,946	17.9
Sustainable Forestry Products	65,353	61,054	-1.0	0.0	18	$44,146	60.1	83.7	$34,442	6.2
Education and Compliance	**95,064**	**142,156**	**5.9**	**0.1**	**15**	**$233**	**29.0**	**59.1**	**$45,865**	**18.6**
Regulation and Compliance	95,064	141,890	5.9	0.1	15	$232	29.0	59.1	$45,879	19.8
Training	0	266	N/A	0.0	21	$768	40.2	50.3	$38,345	7.0
Energy and Resource Efficiency	**675,391**	**830,146**	**3.0**	**0.6**	**16**	**$21,167**	**49.3**	**75.0**	**$38,073**	**11.3**
Appliances	45,671	36,608	-3.1	0.0	21	$56,838	54.0	77.8	$37,980	8.3
Battery Technologies	14,605	16,129	1.4	0.0	8	$81,867	44.9	64.0	$43,011	13.1
Electric Vehicle Technologies	10,264	15,711	6.3	0.0	8.5	$124,825	53.7	78.1	$38,324	18.2
Energy-saving Building Materials	135,911	161,896	2.5	0.1	17	$20,788	58.7	81.6	$36,786	3.4
Energy-saving Consumer Products	23,615	19,210	-2.9	0.0	17	$56,040	49.2	71.4	$40,725	16.9
Fuel Cells	3,542	7,041	10.3	0.0	10	$74,746	33.9	46.1	$50,287	29.6
Green Architecture and Construction Services	36,512	56,190	6.4	0.0	21	$4,908	26.0	32.9	$56,487	32.7
HVAC and Building Control Systems	58,654	73,600	3.3	0.1	17	$46,776	45.0	65.2	$42,806	8.3
Lighting	16,269	14,298	-1.8	0.0	18	$47,922	49.6	71.4	$39,469	24.2
Professional Energy Services	31,161	49,863	6.9	0.0	9	$30,207	20.5	26.2	$56,063	21.8
Public Mass Transit	267,946	350,547	3.9	0.3	21	$53	54.4	90.3	$30,947	11.8
Smart Grid	8,986	15,987	8.6	0.0	10.5	$35,108	33.4	48.2	$48,758	12.8
Water Efficient Products	22,255	13,066	-7.3	0.0	18	$57,487	50.2	72.9	$39,479	17.2

Appendix A. The U.S. Clean Economy by Category and Segment (continued)

Category/Segment	Jobs, 2003	Jobs, 2010	Annual average change in jobs, 2003-2010 (%)	Clean economy share of all U.S. jobs, 2010 (%)	Median age of establishment (in years) 2010	Exports per job, 2009	Share of jobs held by workers with a high school diploma or less, 2010 (%)	Share of jobs jobs that are green collar, 2010 (%)	Average annual wage, 2009	Share of traded sector establishments that are clustered, 2010 (%)
Greenhouse Gas Reduction, Environmental Management, and Recycling	**854,247**	**1,058,886**	**3.1**	**0.8**	**16**	**$19,432**	**45.5**	**69.6**	**$40,644**	**10.3**
Air and Water Purification Technologies	18,072	24,930	4.7	0.0	17	$63,028	47.6	67.9	$39,136	19.6
Carbon Storage and Management	163	391	13.3	0.0	8	$25,678	38.4	55.3	$47,462	14.3
Green Building Materials	69,496	76,577	1.4	0.1	20.5	$32,714	61.1	85.3	$34,191	13.4
Green Chemical Products	28,795	22,622	-3.4	0.0	18	$178,861	48.9	72.8	$39,061	8.1
Green Consumer Products	77,032	77,264	0.0	0.1	18	$48,205	55.4	78.9	$36,069	19.1
Nuclear Energy	66,936	74,749	1.6	0.1	16	$10,733	36.7	66.0	$45,843	12.6
Pollution Reduction	11,024	9,986	-1.4	0.0	18	$27,431	31.0	41.4	$48,133	16.0
Professional Environmental Services	89,253	141,046	6.8	0.1	14	$16,104	20.2	26.7	$55,235	15.7
Recycled-Content Products	56,475	59,712	0.8	0.0	18	$62,637	58.1	85.0	$35,316	11.4
Recycling and Reuse	89,584	129,252	5.4	0.1	17	$1,805	51.3	75.4	$36,463	10.0
Remediation	40,702	56,241	4.7	0.0	14	$1,316	52.9	78.7	$40,101	9.2
Waste Management and Treatment	306,715	386,116	3.3	0.3	16	$3,428	46.6	76.4	$38,795	6.3
Renewable Energy	**111,386**	**138,364**	**3.1**	**0.1**	**6**	**$64,884**	**43.3**	**69.4**	**$43,070**	**14.6**
Biofuels/Biomass	11,384	20,680	8.9	0.0	6	$189,088	45.3	67.1	$41,010	7.9
Geothermal	1,722	2,720	6.7	0.0	12	$8,131	46.8	73.6	$42,772	17.1
Hydropower	71,625	55,467	-3.6	0.0	20	$300	37.5	68.8	$45,226	10.0
Renewable Energy Services	1,294	1,981	6.3	0.0	8	$17,650	40.5	63.6	$46,884	19.6
Solar Photovoltaic	11,866	24,152	10.7	0.0	5	$80,464	45.0	66.7	$43,858	29.4
Solar Thermal	1,647	5,379	18.4	0.0	9	$36,801	53.3	70.8	$35,652	19.6
Waste-to-Energy	2,566	3,320	3.7	0.0	20	$513	49.4	76.6	$40,466	25.9
Wave/Ocean Power	98	371	20.9	0.0	4.5	$11,291	19.6	23.0	$59,368	20.0
Wind	9,184	24,294	14.9	0.0	6	$117,164	49.8	75.1	$40,588	12.0
Aggregate Clean Economy	**2,110,208**	**2,675,545**	**3.4**	**2.0**	**15**	**$20,129**	**44.6**	**68.7**	**$43,773**	**10.9**

Source: Brookings-Battelle Clean Economy Database; exports: Brookings analysis of U.S. International Trade Commission, Bureau of Economic Analysis, Internal Revenue Service, Institute of International Education, and Moody's Analytics data; educational attainment: U.S. Bureau of Labor Statistics Employment Projections Program; green collar jobs: U.S. Bureau of Labor Statistics Occupational Employment Statistics and Employment Projections Program; wages: U.S. Bureau of Labor Statistics Occupational Employment Statistics; clusters: Brookings analysis (see external methods appendix for details).

Appendix B. The Aggregate Clean Economy by State

State	Jobs, 2003	Jobs, 2010	Annual average change in jobs, 2003-2010 (%)	Clean economy share of all state jobs, 2010 (%)	Median age of establishment (in years) 2010	Exports per job, 2009	Share of jobs held by workers with a high school diploma or less, 2010 (%)	Share of jobs jobs that are green collar, 2010 (%)	Average annual wage, 2009	Share of traded sector establishments that are clustered, 2010 (%)
Alabama	32,592	38,182	2.3	1.9	14	$23,684	47.7	72.8	$36,260	1.6
Alaska	8,439	16,682	10.2	4.7	12	$2,294	33.2	56.5	$48,778	1.3
Arizona	29,896	37,257	3.2	1.5	14	$13,504	43.6	68.2	$38,831	14.1
Arkansas	27,920	32,450	2.2	2.6	15	$42,450	49.9	73.7	$32,116	6.6
California	239,064	318,156	4.2	2.1	16	$16,314	43.1	64.2	$46,400	41.0
Colorado	34,787	51,036	5.6	2.2	14	$23,165	38.2	59.7	$45,973	5.5
Connecticut	22,541	29,751	4.0	1.8	16	$11,793	42.5	67.6	$45,802	8.7
Delaware	4,873	6,917	5.1	1.6	15	$13,830	38.7	57.6	$46,607	5.5
District of Columbia	20,302	22,462	1.5	3.1	14	$2,454	38.4	65.4	$52,608	37.5
Florida	74,669	102,967	4.7	1.4	13	$9,386	41.5	65.6	$38,085	2.1
Georgia	64,709	83,707	3.7	2.1	13	$20,216	48.1	72.3	$36,764	10.6
Hawaii	7,144	11,113	6.5	1.7	13	$4,913	42.0	66.1	$42,235	4.7
Idaho	12,992	17,543	4.4	2.7	15	$10,514	42.3	65.2	$36,359	0.7
Illinois	86,084	106,375	3.1	1.8	17	$25,917	45.5	70.7	$41,357	22.4
Indiana	48,352	53,684	1.5	1.9	16	$29,777	48.2	73.0	$37,162	5.5
Iowa	24,574	30,835	3.3	2.0	17	$44,942	51.4	77.0	$35,237	0.8
Kansas	22,179	27,199	3.0	1.9	16	$26,853	43.2	65.4	$38,733	2.0
Kentucky	32,011	36,963	2.1	1.9	16	$39,948	48.1	72.8	$35,585	3.5
Louisiana	28,468	28,673	0.1	1.5	15	$19,443	45.2	70.3	$36,493	2.3
Maine	9,298	12,212	4.0	2.0	18	$14,158	44.1	69.3	$36,460	0.8
Maryland	34,837	43,207	3.1	1.7	15	$9,143	41.3	65.2	$44,790	0.3
Massachusetts	50,598	63,523	3.3	2.0	17	$16,166	42.4	65.4	$47,815	23.1
Michigan	78,537	76,941	-0.3	1.9	17	$26,589	48.6	73.3	$40,558	5.3
Minnesota	41,752	58,232	4.9	2.1	16	$21,868	46.7	70.7	$41,240	10.3
Mississippi	17,730	20,905	2.4	1.8	13	$25,010	50.2	75.1	$31,053	3.5
Missouri	36,496	43,736	2.6	1.6	15	$27,868	44.7	69.4	$38,401	5.4
Montana	11,850	14,235	2.7	3.1	15	$8,970	33.3	54.0	$37,860	0.0
Nebraska	10,286	15,311	5.8	1.5	18	$20,940	45.1	67.6	$36,323	5.8
Nevada	11,167	16,578	5.8	1.5	13	$7,872	39.4	60.3	$44,545	10.9
New Hampshire	8,971	12,886	5.3	2.0	16.5	$14,449	42.8	67.6	$40,773	0.8
New Jersey	68,127	94,241	4.7	2.4	18	$13,639	45.8	72.6	$43,809	4.3
New Mexico	11,818	17,725	6.0	2.1	14	$10,380	37.5	61.6	$39,327	4.2
New York	124,848	185,038	5.8	2.1	18	$13,149	44.6	71.6	$44,056	10.2

Appendix B. The Aggregate Clean Economy by State (continued)

State	Jobs, 2003	Jobs, 2010	Annual average change in jobs, 2003-2010 (%)	Clean economy share of all state jobs, 2010 (%)	Median age of establishment (in years) 2010	Exports per job, 2009	Share of jobs held by workers with a high school diploma or less, 2010 (%)	Share of jobs jobs that are green collar, 2010 (%)	Average annual wage, 2009	Share of traded sector establishments that are clustered, 2010 (%)
North Carolina	52,780	78,881	5.9	1.9	14	$25,774	45.7	70.3	$37,348	9.1
North Dakota	4,537	7,146	6.7	1.7	14	$61,299	47.0	72.4	$35,547	2.7
Ohio	88,513	105,306	2.5	2.0	17	$25,067	45.5	69.9	$39,275	5.1
Oklahoma	13,903	19,297	4.8	1.2	16	$10,491	43.6	71.0	$33,673	0.0
Oregon	50,482	58,735	2.2	3.4	18	$13,484	46.0	68.2	$40,072	6.0
Pennsylvania	99,334	118,686	2.6	2.1	17	$15,709	46.0	71.7	$39,266	10.4
Rhode Island	9,017	9,563	0.8	2.0	14.5	$32,274	45.0	68.9	$41,442	0.0
South Carolina	46,659	50,424	1.1	2.7	15	$38,172	47.0	71.5	$36,373	1.3
South Dakota	5,459	6,659	2.9	1.5	15	$42,092	42.7	69.2	$33,880	0.0
Tennessee	58,456	76,031	3.8	2.8	13	$50,939	42.8	65.5	$37,347	3.4
Texas	115,194	144,081	3.2	1.3	13	$16,703	45.0	68.7	$37,926	28.2
Utah	14,312	18,261	3.5	1.5	14	$10,699	45.2	70.3	$36,637	3.6
Vermont	8,295	9,425	1.8	3.0	15	$22,377	48.2	71.5	$37,681	0.0
Virginia	48,423	66,772	4.7	1.7	14	$11,034	40.6	65.8	$43,400	11.4
Washington	69,106	83,676	2.8	2.8	16	$14,363	44.0	64.9	$46,457	26.0
West Virginia	10,587	12,659	2.6	1.6	17	$12,835	44.0	70.5	$33,805	0.0
Wisconsin	73,093	76,858	0.7	2.7	18	$27,674	50.2	75.3	$37,931	7.5
Wyoming	4,147	6,363	6.3	2.1	14	$5,612	33.3	57.1	$41,603	0.0
United States	**2,110,208**	**2,675,545**	**3.4**	**2.0**	**15**	**$20,129**	**44.6**	**68.7**	**$43,773**	**14.2**

Source: Brookings-Battelle Clean Economy Database; exports: Brookings analysis of U.S. International Trade Commission, Bureau of Economic Analysis, Internal Revenue Service, Institute of International Education, and Moody's Analytics data; educational attainment: U.S. Bureau of Labor Statistics Employment Projections Program; green collar jobs: U.S. Bureau of Labor Statistics Occupational Employment Statistics and Employment Projections Program; wages: U.S. Bureau of Labor Statistics Occupational Employment Statistics; clusters: Brookings analysis (see methods external appendix for details).

**State and metro clustering figures exclude non-exporting segments, defined as those with less than $4000 in exports per job. This is why the clustering figure for the United States seen here does not match the figure in Appendix A.*

Appendix C. The Aggregate Clean Economy in the 100 Largest Metropolitan Areas

Metropolitan Area	Jobs, 2003	Jobs, 2010	Annual average change in jobs, 2003-2010 (%)	Clean economy share of all metro jobs, 2010 (%)	Median age of establishment (in years) 2010	Exports per job, 2009	Share of jobs held by workers with a high school diploma or less, 2010 (%)	Share of jobs jobs that are green collar, 2010 (%)	Average annual wage, 2009	Share of traded sector establishments that are clustered, 2010 (%)
Akron, OH	4,355	5,445	3.2	1.7	16	$11,788	46.4	72.9	$38,120	0.0
Albany-Schenectady-Troy, NY	15,557	28,087	8.8	6.3	15.5	$44,114	34.3	56.6	$48,087	9.1
Albuquerque, NM	5,851	9,912	7.8	2.6	16	$14,180	38.1	61.8	$40,145	6.9
Allentown-Bethlehem-Easton, PA-NJ	5,509	6,770	3.0	2.0	18	$11,992	47.0	74.4	$37,766	0.0
Atlanta-Sandy Springs-Marietta, GA	28,922	43,060	5.9	1.9	12	$15,089	43.2	66.3	$40,602	8.6
Augusta-Richmond County, GA-SC	9,110	6,106	-5.6	2.7	16	$9,331	50.5	77.9	$37,758	0.0
Austin-Round Rock-San Marcos, TX	10,107	14,554	5.3	1.9	12	$10,414	38.9	65.3	$40,441	1.2
Bakersfield-Delano, CA	2,536	3,097	2.9	1.1	18	$6,226	47.1	65.6	$44,005	0.0
Baltimore-Towson, MD	18,927	22,619	2.6	1.7	16	$6,869	40.7	64.1	$44,569	0.5
Baton Rouge, LA	6,695	8,167	2.9	2.2	14	$29,918	40.2	63.0	$39,427	7.4
Birmingham-Hoover, AL	5,296	8,317	6.7	1.7	13	$16,609	47.8	71.0	$37,655	2.6
Boise City-Nampa, ID	5,433	7,456	4.6	2.8	17	$16,815	44.7	69.4	$36,139	1.6
Boston-Cambridge-Quincy, MA-NH	34,032	41,825	3.0	1.7	17	$17,184	42.6	63.8	$51,271	28.9
Bridgeport-Stamford-Norwalk, CT	5,196	6,266	2.7	1.5	19	$16,142	47.6	73.8	$44,251	4.7
Buffalo-Niagara Falls, NY	13,952	14,452	0.5	2.7	16	$5,831	46.8	73.9	$38,017	0.0
Cape Coral-Fort Myers, FL	1,496	2,235	5.9	1.1	10	$23,291	43.1	65.3	$37,131	0.0
Charleston-North Charleston-Summerville, SC	3,014	4,369	5.4	1.5	15	$34,605	45.1	67.8	$37,534	2.3
Charlotte-Gastonia-Rock Hill, NC-SC	11,217	15,485	4.7	1.9	13	$21,303	45.0	69.9	$40,858	10.1
Chattanooga, TN-GA	5,654	6,688	2.4	2.9	11.5	$18,776	49.4	75.8	$35,000	2.4
Chicago-Joliet-Naperville, IL-IN-WI	61,659	79,388	3.7	1.8	16	$25,002	45.3	70.1	$42,816	28.3
Cincinnati-Middletown, OH-KY-IN	14,804	18,525	3.3	1.9	16	$29,922	47.9	74.9	$37,991	2.6
Cleveland-Elyria-Mentor, OH	18,224	24,664	4.4	2.5	18	$33,682	48.1	74.2	$39,213	8.0
Colorado Springs, CO	1,287	1,934	6.0	0.7	16	$2,770	50.3	75.6	$37,605	0.0
Columbia, SC	8,099	8,568	0.8	2.4	16	$5,779	38.5	62.5	$38,621	0.0
Columbus, OH	11,231	15,498	4.7	1.7	18	$22,935	40.0	64.3	$42,340	10.3
Dallas-Fort Worth-Arlington, TX	30,658	38,562	3.3	1.3	14	$23,416	46.3	69.1	$40,105	28.1
Dayton, OH	4,263	6,232	5.6	1.6	16	$20,193	49.0	76.8	$37,574	0.0
Denver-Aurora-Broomfield, CO	20,214	27,929	4.7	2.3	13	$14,279	36.5	59.9	$47,602	8.0
Des Moines-West Des Moines, IA	2,472	5,256	11.4	1.6	15	$9,683	40.9	69.9	$38,671	0.0
Detroit-Warren-Livonia, MI	14,741	20,323	4.7	1.2	17	$21,218	45.0	69.2	$45,642	4.1
El Paso, TX	2,570	2,695	0.7	0.9	12.5	$13,915	46.7	72.2	$29,828	0.0
Fresno, CA	8,308	9,301	1.6	2.8	18	$12,041	47.8	65.0	$38,031	51.1
Grand Rapids-Wyoming, MI	17,232	8,812	-9.1	2.4	18	$39,631	52.4	74.4	$38,203	13.0
Greensboro-High Point, NC	5,086	5,725	1.7	1.7	15	$23,679	50.8	73.9	$35,381	7.6
Greenville-Mauldin-Easley, SC	7,247	10,127	4.9	3.4	14	$86,143	46.0	68.3	$38,193	1.7
Harrisburg-Carlisle, PA	9,091	13,025	5.3	4.0	12	$19,621	34.0	62.7	$43,224	0.0
Hartford-West Hartford-East Hartford, CT	8,812	13,712	6.5	2.2	14	$8,016	37.1	61.1	$48,757	10.8
Honolulu, HI	6,270	9,269	5.7	1.9	12.5	$5,161	42.7	68.1	$42,140	6.8
Houston-Sugar Land-Baytown, TX	27,855	39,986	5.3	1.6	13	$16,926	41.9	63.1	$42,779	74.0

Appendix C. The Aggregate Clean Economy in the 100 Largest Metropolitan Areas (continued)

Metropolitan Area	Jobs, 2003	Jobs, 2010	Annual average change in jobs, 2003–2010 (%)	Clean economy share of all metro jobs, 2010 (%)	Median age of establishment (in years) 2010	Exports per job, 2009	Share of jobs held by workers with a high school diploma or less, 2010 (%)	Share of jobs jobs that are green collar, 2010 (%)	Average annual wage, 2009	Share of establishments that are clustered, 2010 (%)
Indianapolis-Carmel, IN	13,574	15,183	1.6	1.7	15.5	$9,362	37.4	61.5	$41,245	0.0
Jackson, MS	3,370	4,298	3.5	1.7	14	$7,304	43.8	69.5	$32,888	0.0
Jacksonville, FL	5,940	7,679	3.7	1.3	13	$13,928	47.0	68.7	$37,040	4.2
Kansas City, MO-KS	19,832	25,039	3.4	2.5	18	$15,879	41.5	62.9	$42,870	6.8
Knoxville, TN	6,206	16,135	14.6	4.9	11	$20,107	28.1	37.7	$45,184	2.6
Lakeland-Winter Haven, FL	1,985	2,290	2.1	1.1	13	$25,218	48.8	71.9	$34,981	0.0
Las Vegas-Paradise, NV	6,672	9,797	5.6	1.2	9	$5,937	38.0	57.6	$46,590	13.8
Little Rock-North Little Rock-Conway, AR	5,916	11,934	10.5	3.4	14.5	$57,514	47.7	72.1	$33,857	13.2
Los Angeles-Long Beach-Santa Ana, CA	62,807	89,592	5.2	1.7	16	$18,449	46.7	70.9	$40,910	72.8
Louisville-Jefferson County, KY-IN	12,779	14,447	1.8	2.4	17	$36,817	51.5	76.1	$37,317	5.1
Madison, WI	9,215	12,337	4.3	3.5	17	$16,544	39.4	64.8	$43,466	12.2
McAllen-Edinburg-Mission, TX	1,243	2,203	8.5	1.0	11	$5,759	49.5	70.6	$27,981	0.0
Memphis, TN-MS-AR	8,719	11,515	4.1	1.9	13	$40,621	49.5	74.6	$36,138	7.5
Miami-Fort Lauderdale-Pompano Beach, FL	19,688	24,194	3.0	1.1	12	$9,155	42.2	66.6	$38,500	6.7
Milwaukee-Waukesha-West Allis, WI	13,516	13,471	0.0	1.6	19	$29,252	48.1	71.9	$41,031	3.9
Minneapolis-St. Paul-Bloomington, MN-WI	26,519	37,750	5.2	2.2	17	$15,608	45.0	69.5	$44,388	15.8
Modesto, CA	2,974	2,688	-1.4	1.7	18	$10,017	53.9	61.4	$39,279	0.0
Nashville-Davidson--Murfreesboro--Franklin, TN	11,211	17,913	6.9	2.4	13	$17,026	41.3	67.9	$37,705	0.0
New Haven-Milford, CT	4,711	5,636	2.6	1.6	19	$17,974	47.4	72.2	$42,985	13.8
New Orleans-Metairie-Kenner, LA	8,385	7,298	-2.0	1.4	15	$5,604	43.5	70.9	$38,183	0.0
New York-Northern New Jersey-Long Island, NY-NJ-PA	104,185	152,034	5.5	1.8	18	$10,251	47.0	74.4	$45,586	10.8
North Port-Bradenton-Sarasota, FL	2,095	2,409	2.0	1.0	14	$22,719	45.7	70.9	$36,499	0.0
Ogden-Clearfield, UT	1,184	2,111	8.6	1.0	13	$4,657	40.7	62.3	$39,615	0.0
Oklahoma City, OK	4,835	6,854	5.1	1.2	17	$6,716	40.5	67.2	$35,559	0.0
Omaha-Council Bluffs, NE-IA	4,954	7,406	5.9	1.6	18	$11,663	45.0	67.8	$38,057	10.4
Orlando-Kissimmee-Sanford, FL	7,132	11,033	6.4	1.1	14	$11,654	45.3	69.7	$36,408	0.0
Oxnard-Thousand Oaks-Ventura, CA	4,344	5,246	2.7	1.7	18	$21,007	46.6	59.8	$44,449	14.3
Palm Bay-Melbourne-Titusville, FL	6,204	3,446	-8.1	1.7	14	$5,568	42.8	71.0	$37,931	0.0
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	47,752	54,325	1.9	2.0	17	$15,693	45.5	70.3	$43,913	7.6
Phoenix-Mesa-Glendale, AZ	18,814	22,904	2.9	1.3	13	$14,390	45.1	71.1	$38,980	18.6
Pittsburgh, PA	17,025	21,963	3.7	1.9	17	$13,257	46.7	71.9	$37,906	35.9
Portland-South Portland-Biddeford, ME	2,692	3,591	4.2	1.3	18	$12,662	46.8	69.8	$37,612	0.0
Portland-Vancouver-Hillsboro, OR-WA	20,792	27,489	4.1	2.7	18	$13,952	45.0	69.0	$42,548	7.5
Poughkeepsie-Newburgh-Middletown, NY	2,139	2,951	4.7	1.1	17	$6,096	46.0	70.2	$41,635	0.0
Providence-New Bedford-Fall River, RI-MA	11,709	12,904	1.4	1.9	14	$24,971	46.2	71.1	$40,036	0.0
Provo-Orem, UT	1,406	1,587	1.7	0.8	14.5	$18,767	43.4	66.7	$33,374	0.0
Raleigh-Cary, NC	6,788	16,677	13.7	3.3	13	$5,867	37.0	64.0	$40,795	21.9
Richmond, VA	7,723	10,630	4.7	1.7	15	$20,896	45.1	72.8	$40,365	2.6

Appendix C. The Aggregate Clean Economy in the 100 Largest Metropolitan Areas (continued)

Metropolitan Area	Jobs, 2003	Jobs, 2010	Annual average change in jobs, 2003-2010 (%)	Clean economy share of all metro jobs, 2010 (%)	Median age of establishment (in years) 2010	Exports per job, 2009	Share of jobs held by workers with a high school diploma or less, 2010 (%)	Share of jobs jobs that are green collar, 2010 (%)	Average annual wage, 2009	Share of traded sector establishments that are clustered, 2010 (%)
Riverside-San Bernardino-Ontario, CA	17,172	22,532	4.0	1.9	16	$14,924	45.3	65.2	$41,248	15.1
Rochester, NY	7,061	8,385	2.5	1.6	15	$17,289	50.1	75.3	$36,699	0.0
Sacramento--Arden-Arcade--Roseville, CA	23,462	37,319	6.9	4.5	14	$4,975	34.4	62.0	$49,589	34.7
Salt Lake City, UT	7,412	10,539	5.2	1.7	15.5	$13,374	47.6	75.3	$36,251	6.5
San Antonio-New Braunfels, TX	7,938	10,634	4.3	1.2	14	$6,764	47.1	72.4	$34,195	0.0
San Diego-Carlsbad-San Marcos, CA	14,337	22,862	6.9	1.7	15	$17,114	43.3	66.0	$45,016	56.5
San Francisco-Oakland-Fremont, CA	36,027	51,811	5.3	2.7	15	$20,705	37.1	54.7	$59,856	23.3
San Jose-Sunnyvale-Santa Clara, CA	19,360	18,868	-0.4	2.2	12.5	$38,521	44.9	66.6	$55,827	37.1
Scranton--Wilkes-Barre, PA	3,464	4,437	3.6	1.7	18	$10,094	47.6	71.6	$34,780	0.0
Seattle-Tacoma-Bellevue, WA	21,760	31,340	5.3	1.8	16	$10,389	44.1	65.3	$49,128	44.8
Springfield, MA	7,235	10,443	5.4	3.5	17	$4,079	39.1	68.1	$42,657	0.0
St. Louis, MO-IL	15,836	17,553	1.5	1.3	17	$29,792	45.8	68.5	$41,968	3.8
Stockton, CA	3,390	4,642	4.6	2.2	16	$17,374	49.4	75.0	$40,437	0.0
Syracuse, NY	8,272	9,648	2.2	3.0	15	$10,317	46.7	74.4	$39,254	8.5
Tampa-St. Petersburg-Clearwater, FL	10,733	15,347	5.2	1.3	14.5	$11,603	44.3	68.6	$37,300	0.0
Toledo, OH	6,873	11,831	8.1	3.9	16	$25,371	41.7	61.0	$40,276	11.5
Tucson, AZ	3,556	5,327	5.9	1.5	18	$12,627	40.2	63.1	$38,838	9.5
Tulsa, OK	4,076	7,130	8.3	1.7	16	$9,457	43.8	72.6	$34,079	0.0
Virginia Beach-Norfolk-Newport News, VA-NC	8,065	9,594	2.5	1.1	13	$4,883	46.2	72.3	$38,171	0.0
Washington-Arlington-Alexandria, DC-VA-MD-WV	50,425	70,828	5.0	2.3	13	$6,183	37.2	62.3	$51,651	19.8
Wichita, KS	2,811	3,913	4.8	1.3	16	$27,177	47.6	71.6	$36,124	8.3
Worcester, MA	4,914	6,537	4.2	2.0	18	$24,177	47.3	74.0	$41,788	3.2
Youngstown-Warren-Boardman, OH-PA	2,192	2,977	4.5	1.3	15	$4,402	48.3	75.1	$34,923	0.0
100 Largest Metro Areas	**1,276,388**	**1,705,897**	**4.2**	**1.9**	**15**	**$17,255**	**43.6**	**67.7**	**$43,133**	**18.8**

Source: Brookings-Battelle Clean Economy Database; exports: Brookings analysis of U.S. International Trade Commission, Bureau of Economic Analysis, Internal Revenue Service, Institute of International Education, and Moody's Analytics data; educational attainment: U.S. Bureau of Labor Statistics Employment Projections Program; green collar jobs: U.S. Bureau of Labor Statistics Occupational Employment Statistics and Employment Projections Program; wages: U.S. Bureau of Labor Statistics Occupational Employment Statistics; clusters: Brookings analysis (see methods external appendix for details).

**State and metro clustering figures exclude non-exporting segments, defined as those with less than $4000 in exports per job.*

Appendix D. The Clean Economy by Industry (NAICS-Based)

NAICS Code	Industry Title	Jobs, 2010	Share of all clean economy jobs, 2010 (%)
11	Agriculture, Forestry, Fishing and Hunting	31,373	1.2
21	Mining, Quarrying, and Oil and Gas Extraction	1,091	0.0
22	Utilities	155,875	5.8
23	Construction	106,109	4.0
31-33	Manufacturing	687,116	25.7
42	Wholesale Trade	157,476	5.9
44-45	Retail Trade	15,977	0.6
48-49	Transportation and Warehousing	341,041	12.7
51	Information	657	0.0
52	Finance and Insurance	565	0.0
53	Real Estate and Rental and Leasing	718	0.0
54	Professional, Scientific, and Technical Services	278,621	10.4
55	Management of Companies and Enterprises	453	0.0
56	Administrative and Support and Waste Management and Remediation Services	299,409	11.2
61	Educational Services	520	0.0
62	Health Care and Social Assistance	2,115	0.1
71	Arts, Entertainment, and Recreation	253	0.0
72	Accommodation and Food Services	314	0.0
81	Other Services (except Public Administration)	21,067	0.8
92	Public Administration	574,795	21.5

Source: Brookings-Battelle Clean Economy Database

Appendix E. Occupations of the Clean Economy

Occupational Title	Median annual wage, 2009	Share of all clean economy occupations (%)	Share of all U.S. occupations (%)	Share of workers in occupation with with high school diploma or less (%)
High-wage occupations				
Management	$89,330	5.7	4.7	4.7
Legal	$74,030	0.7	0.8	2.7
Computer & math	$72,900	2.1	2.5	1.2
Architecture & engineering	$68,790	5.7	1.8	2.4
Business & financial	$58,910	5.8	4.6	2.1
Life, physical, & social science	$58,300	2.3	1.0	3.3
Healthcare practitioner & technical	$57,690	1.2	5.5	1.2
Education, training, & library	$45,210	0.4	6.5	2.0
Arts, design, entertainment, sports, & media	$42,450	0.6	1.3	4.8
All high-wage occupations	*$63,068*	*24.4*	*28.8*	*2.8*
Middle-wage occupations				
Installation, maintenance, and repair occupations	$39,600	6.2	3.9	27.6
Community and social services occupations	$38,970	1.4	1.4	3.3
Construction and extraction occupations	$38,770	7.2	4.4	51.9
Protective service occupations	$36,170	4.5	2.4	10.5
Office and administrative support occupations	$30,410	14.1	17.1	10.2
Production occupations	$29,970	15.9	6.8	44.2
Transportation and material moving occupations	$28,010	19.3	6.8	43.3
All middle-wage occupations	*$34,557*	*68.7*	*42.9*	*26.5*
Low-wage occupations				
Healthcare support occupations	$24,720	0.3	3.0	23.2
Sales and related occupations	$23,940	3.4	10.5	17.7
Building and grounds cleaning and maintenance occupations	$22,350	0.9	3.3	66.6
Personal care and service occupations	$20,770	1.2	2.6	23.7
Farming, fishing, and forestry occupations	$19,610	0.7	0.3	18.2
Food preparation and serving related occupations	$18,490	0.4	8.6	49.6
All low-wage occupations	*$21,647*	*6.9*	*28.3*	*34.2*

Source: 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) were 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. See external methods appendix for more details.

ENDNOTES

CHAPTER 1

1. See Allison Hannon and others, "Delivering Low Carbon Growth: A Guide to China's 12th Five-Year Plan" (London: Climate Group and HSBC, 2011).
2. Chico Harlan, "Japan Takes a Shine to Renewable Energy." *The Washington Post*, May 27, 2011.
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CHAPTER 2

1. For important reviews of the environmental, security, and economic challenges associated with the world's present development path, with a focus on the energy portion of the "green" concern, see Michael Greenstone and Adam Looney, "A Strategy for America's Energy Future: Illuminating Energy's Full Costs" (Washington: Hamilton Project/ Brookings Institution, 2011) and Jason Furman and others, "An Economic Strategy to Address Climate Change and Promote Energy Security" (Washington: Hamilton Project/Brookings Institution, 2007).
2. United Nations Environment Program, "Global Environmental Outlook 4" (New York: 2007). United Nations Environment Program, "Towards a Green Economy" (Paris: 2011). Deutsche Bank Climate Change Advisors, "Investing in Climate Change 2010: A Strategic Asset Allocation Perspective" (New York: January 2010).
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CHAPTER 3

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6. Since 1990, the firm Dun & Bradstreet has aimed to create a census of U.S. establishments and their employees. They 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 & Bradstreet kept the older system that they had developed. Walls & Associates has developed a "cross-walk" between D&B's SIC and the contemporary NAICS, which was used in this report.

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10. The following changes were made to the BLS categories: Public awareness was dropped from the category "Education and Compliance" (and considered here as a clean economy "process job" rather than a production job); "Energy Efficiency" was broadened to include resource efficiency (e.g. water); Agriculture was added to "Natural Resources Conservation;" and "Pollution Reduction and Removal" was changed to "Environmental Management."

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15. Elliot Martin and others, "Impact of Carsharing on Household Vehicle Holdings: Results from North American Shared-Use Vehicle Survey," *Transportation Research Record* 2143 (2010): 150-158.

16. Ibid.

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24. See the Solar Foundation website, available at http://www.thesolarfoundation.org/sites/thesolarfoundation.org/files/Final%20TSF%20National%20Solar%20Jobs%20Census%202010%20Web%20Version.pdf

25. See the National Hydropower Association website, available at http://hydro.org/wp-content/uploads/2011/02/NHA-Annual-Conf-Frantzis-pres-Final-7.pdf

26. See the American Wind Industry Association website, available at www.awea.org/_cs_upload/learnabout/publications/5094_1.pdf

27. See the Geothermal Energy Association website, available at http://geo-energy.org/geo_basics_employement.aspx

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

CHAPTER 4

1. The figure is for 2010, and the source is Moody's Economy.com. NAICS 621, 622, and 623 were included. Social assistance was excluded.

2. Brookings analysis of 2009 Census County Business Patterns data shows that jobs associated with producing fossil fuel based energy, derivative products, and machinery make up roughly one percent of the U.S. economy. If one adds distribution, gas stations, fuel transportation, and wholesalers—peripheral activities excluded from the clean economy estimates—the fossil fuel economy still employs only 1.8 percent of U.S. workers or 2.4 million workers. A 2009 report from Pricewaterhouse Coopers estimated that the number of jobs directly involved in the fossil fuel industry was 2.1 million; that report was commissioned by the American Petroleum Institute. (See Pricewaterhouse Coopers, "The Economic Impacts of the Oil and Natural Gas Industry on the U.S. Economy: Employment, Labor Income and Value Added" (2009).

3. Battelle and Biotechnology Industry Organization, "State Bioscience Initiatives 2010" (2010).

4. The source of these data is Moody's Economy.com special aggregates, IT-Producing Industries. Estimates are for 2010.

5. See the *GoodGuide*, available at www.goodguide.com/about/methodology. *GoodGuide* is a "for benefit" corporation, or B Corporation.

6. Growth data here refer to job gains from openings and expansions, as well as job losses from contractions. They exclude job losses from the closing of establishments, because that data was not available for the clean economy. The national data also excludes jobs lost from closings to create a comparable set of businesses. This can be done by subtracting the number of deaths over the period (2003 to 2010) from the base year (2003). This creates a universe of survivors. The underlying national data is from the Bureau of Labor Statistics' Business Employment Dynamics series.

7. John C. Haltiwanger, Ron S. Jarmin, and Javier Miranda, "Who Creates Jobs? Small Vs. Large Vs. Young." Working Paper 16300 (National Bureau of Economic Research, 2009).

8. The median year of establishment birth in the clean economy is 1995. Analysis of Business Dynamics Statistics and the Bureau of Employment Dynamics data show that the average year of establishment birth is between 1994 and 1997 for the U.S. economy. Start years for the hydropower segment were missing for all but three observations out of 1400 establishments. The median start year for those three was 1990. Caution should be used in interpreting these figures. The true median start year is probably earlier. However, the Federal Energy Regulatory Commission database reports the date of licenses issued to hydroelectric producers. The median year for these licenses is also 1990. See www.ferc.gov/industries/hydropower.asp

9. See the external methods appendix for details. These figures reflect Brookings analysis of data from the BLS's Business Employment Dynamics series. All subsequent deaths were subtracted from the base year to account for job losses due to closings and make the data comparable to the clean economy. Nationally, old establishments—born before 2003—lost jobs at a rate of -0.5 percent per establishment per year.

10. Data on U.S. manufacturing from Moody's Economy.com. This number is the sum of manufacturing employment in the 50 states, not for the United States and its territories.

11. These data are from the BLS Business Employment Dynamics program. The 3.3 million figure is net of openings, expansions, contractions, and closings. The comparable number to the clean economy would be 1.3 million looses—that excludes job losses from establishments that closed.

12. These data are estimated based on a technique described in the methods section and external methods appendix. It estimates exports at the establishment level based on the establishment's industry. However, the use of an alternative method to estimate exports yields similar results. Evidence from the International Trade Administration (ITA) paints an encouraging picture on exports in the clean economy—which is associated with environmental technologies. According to a Brookings analysis of an ITA list of 228 products deemed to be environmental technologies, the United States exports 60 percent more in environmental goods than it imports. Moreover, the share of U.S. manufacturing exports from environmental technologies increased from 2.9 in 1996 to 4.5 in 2009. Overall, the definition used by the ITA is very similar to the Brookings definition used here. Employing the ITA's product codes, the value of environmental exports—excluding services—comes to almost $40 billion in 2010.

13. 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.

14. All the growth figures here exclude establishments that may have closed between 2003 and 2010.

15. Gilles Duranton and Diego Puga, "Nursery Cities: Urban Diversity, Process Innovation, and the Life Cycle of Products," *American Economic Review* 91 (5) (2001): 1454-1477.

16. This excludes establishments that may have closed in intervening years.

17. Exporting establishments are defined as those with above average exports per worker, meaning above $20,000.

18. Details describing how this result was obtained are discussed in the external methods appendix. To summarize, establishment level employment growth was regressed on establishment characteristics including age, headquarters status, branch status, three-digit industry, county level employment, company level employment, the number of establishments in the company, and county level segment employment in other establishments. Errors were allowed to cluster at the county level.

19. Methodologically, establishments were defined as concentrated in clusters if other establishments in the same county comprised at least 1 percent of all U.S. employment for the given segment in the base year of 2003. By this standard, 47.3 percent of all establishments were in clusters. The results are not substantially changed if the definition is relaxed or made more discriminating. Using a threshold of 0.01 percent for the county share of U.S. employment, which includes 73 percent of all establishments, clustered establishments grew at 4.6 percent on average, compared to 3.2 percent for isolated establishments. Using a stricter threshold of 1 percent, which applies to just 11 percent of establishments in the clean economy, those that were clustered grew at a rate of 5.3 percent, compared to 3.4 percent for non-clustered establishments. In other words, using any reasonable definition of concentration, clean economy establishments benefitted from being located in concentrated clusters of peer establishments in the same segment.

20. See, among others, J. Vernon Henderson, "Marshall's Scale Economies," *Journal of Urban Economics* 53 (2003): 1-28; Stuart Rosenthal and William Strange, "Evidence on the Nature and Sources of Agglomeration Economies." In J.V. Henderson and J. F. Thisse, eds., *Handbook of Regional and Urban Economics*, vol. 4 (Amsterdam: North-Holland, 2004); Gilles Duranton, Philippe Martin, Thierry Mayer and Florian Mayneris, The Economics of Clusters: Lessons from the French Experience (Oxford: Oxford University Press, 2010). Clusters benefit economic performance through three mechanisms, according to the work of Giles Duranton and colleagues: sharing, learning, and matching. Sharing is facilitated in clusters in that proximity allows firms to share things like facilities, transportation infrastructure, and even institutions (like universities or federal labs). Clusters may reduce the costs of establishing or maintaining these valuable resources. Learning is facilitated in clusters through knowledge diffusion, which has proven to be easier over short distances, whether it be via teaching, casual conversation, or employees transferring to rival firms or starting-up their own. Finally, clusters can improve matching between workers and employers or suppliers and buyers. (For details see: Peter Thompson, "Patent Citations and the Geography of Knowledge Spillovers: What do Patent Examiners Know?" *The Review of Economics and Statistics* 88 (2) (2006): 383-388; Matt Marx, Deborah Strumsky, Lee Fleming, "Mobility, Skills, and the Michigan Non-Compete Experiment," *Management Science* 55 (6) (2009): 875-889; Toby Stuart and Olav Sorenson, "Liquidity Events, Noncompete Covenants, and the Geographic Distribution of Entrepreneurial Activity," *Administrative Science Quarterly* 48 (2003): 175-201.

21. That calculation takes (1130/190)^0.03, where 0.03 is the coefficient on cluster size for a regression of the log of 2003 jobs at an establishment on the log of county level employment of other establishments in the same segment. See the external methods appendix for details.

22. Zoltan J. Acs and Pamela Mueller, "Employment Effects of Business Dynamics: Mice, Gazelles and Elephants," *Small Business Economics* 30 (2008): 85-100.

23. The numbers reported are the collective growth rates of all clustered and all isolated establishments. At the level of the individual establishment, the average annual compound growth rate was 4.2 percent versus 3.4 percent in favor of clustered establishments. This difference was statistically significant with a p-value of less than 0.01.

24. These low-exporting segments were as follows: waste management and treatment, recycling and reuse, remediation, training, waste-to-energy, conservation, hydropower, regulation and compliance, and public mass transit. It was deemed that clustering dynamics (or agglomeration economies in the technical jargon) are less relevant for these sectors because there is little private-sector competition and they are untraded. However, some of the advantages of clustering could still work to increase efficiency and productivity in these segments.

CHAPTER 5

1. See Bloomberg New Energy Finance, "Weathering the Storm: Public Financing for Low-Carbon Energy in the Post-Financial Crisis Era" (Washington, 2010) and DBCCA, "Investing in Climate Change 2011."

2. Bloomberg New Energy Finance data on U.S. and Chinese asset finance from 2004 to 2010 show that while financings have grown in both nations, China has far outpaced the U.S. in the last few years. Chinese asset financings increased from $1.5 billion in 2004 to $47.3 billion in 2010. By contrast, U.S. asset investment grew much more slowly, rising from $2.8 billion in 2004 to $21.9 billion in 2008 before slipping to $20.7 billion in 2010—a level less than half the Chinese amount.

3. Data through 2008. "Environmental Technologies Industries: FY2010 Industry Assessment" (Washington: International Trade Administration, 2010). U.S. Ron Senator Wyden's much-referenced reports on U.S. trade in environmental goods, which track a basket of 43 climate-friendly environmental technology products, confirm this broad trend through 2009. See "U.S. Trade in Environmental Goods: Updated Report to Major Opportunities and Challenges to U.S. Exports of Environmental Goods" (Washington: Office of Senator Ron Wyden, December 2010).

4. Google and Good Energies, an investment firm specializing in renewable energy, each agreed to take 37.5 percent of the equity portion of the transmission line project at a cost of $200 million each. Envision: Charlotte is a first-of-a-kind collaborative partnership among major employers, building owners and managers along with municipal and technology leaders to create the most environmentally sustainable urban core in the nation.

5. See, for example, Rebecca Henderson and Richard G. Newell, "Introduction and Summary." in Rebecca Henderson and Richard G. Newell, eds., *Accelerating Energy Innovation: Insights from Multiple Sectors.* (Cambridge: National Bureau of Economic Research, forthcoming). Available at www.nber.org/books/hend09-1/. This sort of argument has also been made by Richard Kauffman in "Has China Won the U.S. Solar War? *Huffington Post,* January 19, 2011. See also Richard Newell, "The Role of Markets and Policies in Delivering Innovation for Climate Change Mitigation," *Oxford Review of Economic Policy* 26 (2010): 253-269.

6. See, Michael Porter, *The Competitive Advantage of Nations* (New York: Free Press, 1990).

7. To be sure, narrow segments of the clean economy, such as energy-saving consumer products, green building materials, or solar photovoltaic, face very specific market making challenges and it is beyond the scope of this report to go into detail for each of those. The report attempts to highlight some high level, salient problems that impede the growth of the entire clean economy or significant chunks of it.

8. See, for example, Greenstone and Looney, "A Strategy for America's Energy Future."

9. See, for example, Newell, "The Role of Markets and Policies." See also, Carolyn Fischer and Richard Newell, "Environmental and Technology Policies for Climate Mitigation," *Journal of Environmental Economics and Management* 55 (2) (2008). And, Carolyn Fischer, "The Role of Technology Policies in Climate Mitigation." Issue Brief #09-08 (Washington: Resources for the Future, July 2009).

10. See Bloomberg New Energy Finance, "Crossing the Valley of Death" (New York, 2010) for a discussion on how governments, as first adopters, can play a direct role in fostering clean technologies.

11. Kate Manuel and L. Elaine Halchin, "Environmental Considerations in Federal Procurement: An Overview of the Legal Authorities and Their Implementation," CRS Report for Congress (June 2010). There is also the problem that environmental objectives compete with other policy objectives and interests such as obtaining high quality goods at low prices through competition, protecting American manufacturing from foreign competition, and ensuring opportunities for small businesses. See also Eric Fischer, "Green Procurement: Overview and Issues for Congress," (Washington: Congressional Research Service, April 2010).

12. See Blair Hamilton, "Developing Effective and Sustainable Financing Approaches." In *Scaling Up Building Energy Retrofitting in U.S. Cities* (Montpelier, VT: Institute for Sustainable Communities, June 2009). See also, Merrian Fuller, "Enabling Investments in Energy Efficiency: A Study of Programs that Eliminate First Cost Barriers for the Residential Sector" (Burlington, VT: Efficiency Vermont, August 2008). See Derek Supple, "Financing Models for Energy Efficiency and Renewable Energy in Existing Models" (Milwaukee: Institute for Building Efficiency and Johnson Controls, September 2010). Johnson Controls and the international Facility Management association (iFMa) surveyed over 1400 executives with budget responsibility for their company's facilities during the spring of 2009. When asked what the top barrier for energy efficiency was, the most frequent response amongst managers, consistent across a wide variety of industries, was capital availability.

13. Deep energy retrofit packages can cost anywhere from $6,000 to $20,000 per home and require longer financing with terms of 10 to 20 years. Direct cash incentives such as rebates and grants do not completely cover the full upfront cost of clean energy investment. In this regard, many states, municipalities and utilities are continuing to offer traditional financing programs (e.g., revolving loan funds, energy savings performance contracting) and experiment with innovative financing mechanisms (e.g., utility on-bill financing, property assessed clean energy) that can operate in parallel with rebates and grants, lowering the cost of the project and shortening the payback period for financing. However, these financing programs have also not been widespread or designed to offer a large number of loans and come with their own specific challenges in design and implementation. For a review of various clean energy financing mechanisms, see Devashree Saha, Sue Gander, Greg Dierkers, "State Clean Energy Financing Guidebook" (Washington: National Governors Association Center for Best Practices, January 2011).

14. ARRA represents a one-time historic infusion of funds that is expected to be temporary. For instance, DOE funded the State Energy Program (SEP) at $25 million each in FY 2009 and FY 2010 in SEP formula funding, and ARRA provided $3.1 billion for SEO formula grants. For FY 2011, SEP received $50 million, with $39 million of that amount in formula funding and the rest in technical assistance support. DOE funded the Weatherization Assistance Program (WAP) at $250 million in FY 2009, and ARRA provided $5 billion. For FY 2011, WAP received $174.3 million. See www.naseo.org/news/releases/2011-05-20.pdf.

15. For an overview of the characteristics of the water and wastewater sector and the challenges it faces see Haarmeyer and Coy, "An Overview of Private Sector Participation."

16. See, for instance, Marilyn Brown and Sharon Chandler, "Governing Confusion: How Statutes, Fiscal Policy, and Regulations Impede Clean Energy Technologies," *Stanford Law and Policy Review* 472 (19) (2008). See also Benjamin Sovacool and Chistopher Cooper, "Congress Got It Wrong: The Case for a National Renewable Portfolio Standard and Implications for Policy," *Environmental and Energy Law and Policy Journal* 85 (3) (2008); and Lincoln Davis, "Power Forward: The Argument for a National RPS," *Connecticut Law Review* 42 (5) (July 2010).

17. Richard Lester and David Hart, "The Great Unlocking: A Comprehensive Energy Innovation Strategy for the U.S." Discussion draft (Industrial Performance Center, Massachusetts Institute of Technology, 2011)

18. The Senate Committee on Energy and Natural Resources (ENR) released a Clean Energy Standard White Paper in March 2011 that lays out key questions and potential design elements of a CES. The white paper solicited inputs from stakeholders to inform the early consideration of a national CES by the ENR Committee. For more details, see www.energy.senate.gov/public/_files/CESWhitePaper.pdf. However, it does not seem likely that a "clean energy standard" is forthcoming anytime soon. See, for example, "Outlook Bleak for Passing CES, Repealing Oil Subsidies – Bingaman." *Greenwire*, May 16, 2011.

19. The Center for American Progress and the Coalition for Green Capital have advanced the concept of "races to the top" in the clean energy realm in Bracken Hendricks and others, "Cutting the Cost of Clean Energy 1.0" (Washington: Center for American Progress and the Coalition for Green Capital, 2011).

20. The greening of federal activities and the use of federal procurement to create stable market demand has been an object of bipartisan interest in both Congress and the executive, through both Republican and Democratic administrations. More recently, in response to Executive Order on Federal Leadership in Environmental, Energy, and Economic Performance (EO 13514) signed by President Obama in 2009, federal agencies have released Strategic Sustainability Performance Plans that outline how they will achieve the environmental, energy, and economic goals set forth in the executive order. This is the first time that federal agencies have developed and submitted detailed sustainability plans. See www.whitehouse.gov/administration/eop/ceq/sustainability/plans. For a discussion of how energy and environmental innovation has been driven by Department of Defense procurement through both the Bush and Obama administrations, see Matthew Hourihan and Matthew Stepp, "Lean, Mean, and Clean: Energy Innovation and the Department of Defense" (Washington: Information Technology and Innovation Foundation, 2011).

21. More ambitious reforms would make an even bigger difference. For instance, Congress should help strengthen FERC's authority to promote these reforms and make electricity markets more competitive by revising the Federal Power Act.

22. States have taken action in several policy areas that are driving the demand for clean energy investment. 36 states have renewable portfolio standards or goals and 24 states have energy efficiency resource standards or goals. 43 states have adopted a net metering policy and 41 states have adopted an interconnection policy. 21 states have public benefit funds (PBFs) supporting energy efficiency and 16 have PBFs for renewable energy. 11 states have adopted the most recent building energy codes or more stringent codes in the residential sector (IECC 2009); 15 have done so in the commercial sector (ASHRAE 90.1-2007). 47 states have one or more tax incentives supporting renewable energy; 24 states have one or more tax incentives directed at energy efficiency. For more information, see Rachel Escobar and Sue Gander, "Clean and Secure State Energy Actions – 2010 Update" (Washington: National Governors Association, August 2010). See also the Database of State Incentives for Renewables and Efficiency (DSIRE) Summary Maps, available at www.dsireusa.org/summarymaps/index.cfm.

23. As state RPS experience accumulates, studies have begun to evaluate RPS impact and effectiveness. See Langniss and Wiser, "The Renewable Portfolio Standard in Texas: An Early Assessment," *Energy Policy* 31 (6) (2003). This study reports positive initial results from the establishment of RPS in Texas. See also Carley, "State Renewable Energy Electricity Policies: An Empirical Evaluation of Effectiveness," *Energy Policy* 37 (8) (2009) and Powers and Yin, "Do State Renewable Portfolio Standards Promote In-State Renewable Generation?" *Energy Policy* 38 (5) (2010). Both studies credit RPS implementation with increasing total renewable energy generation across the nation. More recently, the implementation over time of RPS standards has been credited with significantly expanding installed wind capacity in both Colorado and Texas. Installed

wind capacity grew by a factor of five between 2004–2007 after Colorado's RPS came into effect in 2004, and similarly Texas witnessed a quintupling of installed capacity in the four years following the passage of its RPS in 2005. See Joshua Freed, Elizabeth Horwitz, and Nicholas Cunningham, "A Clean Energy Standard: Getting the United States Back Into the Clean Energy Race" (Washington: Third Way, March 2011).

24. Examples of states that have ratcheted up their electricity sourcing targets include Colorado, which has twice updated its RPS, and Nevada, which increased its RPS target in 2009. Resource eligibility has expanded beyond traditional renewable energy resources to cover energy efficiency and other supply-side technologies. For a more detailed discussion on state revisions of RPS, see Ryan Wiser and Galen Barbose, "Renewable Portfolio Standards in the United States: A Status Report with Data Through 2007" (Berkeley: Lawrence Berkeley National Laboratory, 2008). For background on state-by-state RPS coverage visit the Pew Center on Global Climate Change at www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm.

25. States have been leveraging their procurement power to drive the clean economy revolution through advanced energy efficiency and renewable energy requirements for new and existing publicly funded buildings, facilities, and fleets; energy efficient and green product procurement (for instance, requiring all appliances and equipment purchases to meet the ENERGY STAR requirement); and using renewable energy either through generation at public facilities or on public lands, or by purchasing renewable energy directly from the electricity provider in what is popularly called green power purchasing. For more details on state best practices, see Maria Ellingson and Lesley Hunter, "Compendium of Best Practices: Sharing Local and State Successes in Energy Efficiency and Renewable Energy from the United States" (Renewable Energy and Energy Efficiency Partnership, Alliance to Save Energy, and American Council on Renewable Energy, May 2010). See also Alison Partin, "Greening State Government: 'Lead by Example' Initiatives" (Washington: National Governors Association, July 2008). For further details on how states can maximize their efforts by designing comprehensive programs, see U.S. Environmental Protection Agency, "Clean Energy Lead by Example Guide" (June 2009). Available at www.epa.gov/statelocalclimate/documents/pdf/epa_lbe_full.pdf. See also ACEEE, "How State Governments can Lead by Example" at www.aceee.org/files/pdf/fact-sheet/State%20Toolkit_Lead%20by%20Example.pdf.

26. See Saha and others, "State Clean Energy Financing Guidebook." The Department of Energy's Solution Center highlights nine particularly effective financing mechanisms: state and municipal revolving loan funds, third party loans, energy savings performance contracting, property-assessed clean energy, on-bill repayment, energy efficient mortgages, power purchase agreements, FHA Power Saver, and qualified energy conservation bond programs. See www1.eere.energy.gov/wip/solutioncenter/financialproducts/financingprograms.html.

27. American Wind Energy Association and Solar Energy Industry Association, "Green Power Superhighways Building a Path to America's Clean Energy Future" (2009); William W. Hogan, "Electricity Wholesale Market Design in a Low Carbon Future." In Jorge Padilla and Richard Schmalensee, eds., Harnessing Renewable Energy (Washington: Resources for the Future Press, 2010).

28. See, for instance, the IEA's report providing guidance to local policymakers to enhance the deployment and use of renewable energy resources within their geographic boundaries. International Energy Agency, "Cities, Towns and Renewable Energy: Yes in my Front Yard," (2009).

29. See the Playbook for Green Buildings available at www.greenplaybook.org/buildings/index.htm

30. For instance, the global C40 Cities Climate Leadership Group, chaired by New York City Mayor Bloomberg, recently released its flagship report in which 36 global cities—including Austin, Chicago, Los Angeles, New Orleans, New York, Philadelphia, Portland, Seattle, and San Francisco—disclose their carbon emissions. The report will inform cities' emissions-reduction efforts and establish a benchmark for judging the effectiveness of present and future policies. KPMG Advisory N.V., "CDP Cities 2011: Global Report on C40 Cities," report prepared for C40 Cities Climate Leadership Group (2011).

31. See, for example, BNEF, "Crossing the Valley of Death."

32. Ibid.

33. Clear analyses of the "commercialization Valley of Death" can be found in BNEF's "Crossing the Valley of Death" and Eliot Jamison, "From Innovation to Infrastructure: Financing First Commercial Clean Energy Projects" (San Francisco: CalCEF, 2010).0.

34. The Solar Energy Industries Association, for one, has complained about long processing delays associated with the Loan Guarantee Program's multi-agency review process as well as recent budget-related "holds" on pending applications. See Solar Energy Industries Association, www.seia.org/galleries/FactSheets/Factsheet_DOE_LGP.pdf as well as www.seia.org/galleries/pdf/SEIA_Letter_to_Congressional_Leaders_on_LGP_5.11.11.pdf.

35. Jamison, "From Innovation to Infrastructure." See also Jenny Mandel, "Loan Guarantee Program's Financial Rigor Slows it Down." *E&E News*, April 1, 2011.

36. For a good discussion of these and other flaws in the structure and nature of renewable energy subsidies see Nate Gorence and Sasha Mackler, "Reassessing Renewable Energy Subsidies" (Washington: Bipartisan Policy Center, 2011).

37. Originally enacted in 1992, the PTC has been renewed and expanded numerous times, most recently through the Energy Improvement and Extension Act of 2008 and the American Recovery and Reinvestment Act (ARRA) of 2009. Through ARRA, Congress acted to provide a three-year extension of the PTC through December 31, 2012. Wind projects must be in place before January 1, 2013 and other projects in general before January 1, 2014. For more details, see American Wind Energy Association, "What is the Current Status of the Production Tax Credit." Available at www.americanwindenergyassociation.net/ei_policy_ptc.cfm. The ITC similarly has gone through several revisions, most notably through the Energy Improvement and Extension Act of 2008 and subsequently under ARRA. Through ARRA, qualifying wind projects can, for a limited time, choose between a 30 percent ITC or a 30 percent cash grant in lieu of the PTC.

38. For background on CEDA, see Senate Committee on Energy & Natural Resources, "The 21st Century Energy Technology Deployment Act" (April 2009). Available at www.energy.senate.gov/public/_files/CEDAOnePageSummary.pdf. For more recent arguments in support of CEDA see the testimonies of Dan Reicher, Christopher Guith, and Kassia Yanosek before the Senate Energy & Natural Resources Committee on May 3, 2011. Available at www.energy.senate.gov/public/index.cfm?FuseAction=Hearings.Hearing&Hearing_ID=929b04b3-bbb7-c4d3-c14a-e477af7b1291. For discussion of the so-called Energy Independence Trust model see Hendricks and others, "Cutting the Cost of Clean Energy 1.0." For discussions of capital repatriation schemes as sources of investment finance see Reed Hundt and Thomas Mann, "Rebuild American Infrastructure? Companies' Offshore Profits Can Help." *Washington Post*, June 16, 2011 and Elise Zoli and Peter Rothstein, "Repatriation to Accelerate Clean Energy (RACE): New Private Capital for Cleantech Investment and Deployment on a Pilot Scale." Presentation, April 22, 2011.

39. For discussions of the need to restructure renewable energy investment incentives see Steven Hayward and others, "Post-Partisan Power" (Oakland: The Breakthrough Institute, 2010) and Gorence and Mackler, "Reassessing Renewable Energy Subsidies," which provides a rich discussion of the problems, potential solutions, and the political moment.

40. Gorence and Mackler, "Reassessing Renewable Energy Subsidies" provides a detailed discussion of reverse auctions.

41. For information on Connecticut's programs see the CDA's technology oriented expansion finance programs see www.ctcda.com/Financing/Specialty_Programs/TECHNOLOGY_INTENSIVE. For more information on the California alternative vehicle program see the California Energy Commission website at www.energy.ca.gov/altfuels/index.html.

42. This concept is described in Jamison, "From Innovation to Infrastructure."

43. See BNEF, "Crossing the Valley of Death."

44. On the general importance of innovation to economic growth see Robert Atkinson and Howard Wial, "Boosting Innovation, Productivity, and Growth Through a National Innovation Foundation" (Washington: Brookings Institution, 2008). See also, on the energy field, and Richard Newell, "A U.S. Innovation Strategy for Climate Change Mitigation" (Washington: Brookings Institution / Hamilton Project, 2008). James Duderstadt and others, "Energy Discovery-Innovation Institutes: A Step Towards America's Energy Future" (Washington: Brookings Institution, 2009); and Hayward and others, "Post Partisan Power." and Hourihan and Atkinson, "Inducing Innovation."

45. See, among many others, Duderstadt and others, "Energy Discovery-Innovation Institutes" and Hayward and others, "Post Partisan Power." In the energy field, the "levelized" costs of new renewable electricity technologies remain substantially higher than conventional coal and natural gas-fired fossil power plants, according to the U.S. Energy Information Administration. For plants entering service in 2016, these estimates suggest that while the costs of conventional coal-fired plants going online in 2016 would come in at about $95 per megawatt hour (MWh), those for onshore wind generation clock in at $97, for geothermal at $101, and for advanced nuclear at $113. Solar PV generation will run to $211, offshore wind $243, and solar thermal to $312. See U.S. Department of Energy, "2016 Levelized Cost of New Generation Resources from the Annual Energy Outlook 2010" (Energy Information Administration). Available at www.eia.doe.gov/oiaf/aeo/electricity_generation.html. The International Energy Agency similarly writes that "a global revolution is needed in the ways that energy is supplied and used" and outlines detailed roadmaps for both the incremental and dramatic innovations necessary to enable "all countries to put in motion a transition to a more secure, lower-carbon energy [system], without undermining economic growth." International Energy Agency, "Energy Technology Perspectives 2008" (Paris, 2011).

46. For an early review of the literature see David Mowery and Nathan Rosenberg, "The Influence of Market Demand upon Innovation: A Critical Review of Some Recent Empirical Studies," *Research Policy* 8 (2) (1979). More recent treatments of the interplay of "induced" and "pushed" innovation include: Adam Jaffe, Richard Newell, and Robert Stavins, "Environmental Policy and Technological Change," *Environmental and Resource Economics* 22 (1-2) (2002); Adam Jaffe, Richard Newell, and Robert Stavins, "A Tale of Two Market Failures: Technology and Environmental Policy," *Ecological Economics* 54 (2005): 164–174; Gregory Nemet, "Demand-Pull, Technology-Push, and Government-Led Incentives for Non-Incremental Technical Change," *Research Policy* 38 (2009): 700–709; and David Popp, Richard Newell, and Adam Jaffe, "Energy, the Environment, and Technological Change." Working Paper. (Cambridge: National Bureau of Economic Research, 2009). See also Duderstadt and others, "Energy Discovery-Innovation Institutes;" Hayward and others, "Post Partisan Power;" and Matt Hourihan and Robert

Atkinson, "Inducing Innovation: What a Carbon Price Can and Can't Do" (Washington: Information Technology and Innovation Foundation, 2011).

47. Among the numerous market failures and barriers that prevent private firms from adequately investing in the development of new, high-risk energy and environmental technologies and business models are: the high relative price of new technologies; knowledge spillover risks; uncertainty about the present and future regulatory environment and prices; the heavy requirements of new infrastructure required by many new energy technologies; and the scale and long time-horizon of many projects. See Marilyn Brown, "Market Failures and Barriers as A Basis for Clean Energy Policies," *Energy Policy* 29 (2001): 1197–1207; Jaffe and others., "A Tale of Two Market Failures;" Atkinson and Wial, "Boosting Productivity;" and Duderstadt and others, "Energy Discovery-Innovation Institutes."

48. See, for example, Newell, "A U.S. Innovation Strategy for Climate Change Mitigation" and Duderstadt and others, "Energy Discovery-Innovation Institutes." See also American Energy Innovation Council, "A Business Plan for America's Energy Future" (Washington, 2010); President's Council of Advisors on Science and Technology, "Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy" (The White House, November 2010); and Heyward and others, "Post Partisan Power."

49. K.S. Gallagher and L.D. Anadon, "DOE Budget Authority for Energy Research, Development, and Demonstration Database," Energy Technology Innovation Policy, John F. Kennedy School of Government, Harvard University, March 3, 2011. Figures reported are the sum total of the "Total Energy Technology RD&D" and "Basic Energy Sciences" budgets in 2005 dollars. The assessment here includes Basic Energy Sciences (BES) (while others do not) because BES funds some of the Department of Energy's most innovative programs beyond ARPA-E like the Energy-Regional Innovation Clusters (E-RIC) and Energy Frontier Research Centers (EFRCs), in addition to energy-related fundamental research at institutions across the country. Other transparent and similarly legitimate tabulations choose to exclude BES and arrive at lower estimates of energy R&D accordingly. The Energy Innovation Tracker at http://energyinnovation.us/ is a particularly good resource. It should be noted too that the Recovery Act has already pumped over $22 billion into the third and growing "D:" deployment.

50. See Duderstadt and others, "Energy Discovery-Innovation Institutes" and American Energy Innovation Council, "A Business Plan for America's Energy Future." See also Mark Muro and Sarah Rahman, "$15 billion: The New Energy Target." The Avenue, a blog of *The New Republic*, November 2, 2009.

51. Organization for Economic Cooperation and Development iLibrary, "Government Budget Appropriations or Outlays for R&D by Socioeconomic Objective," accessed May 11, 2011 and available at www.oecd-ilibrary.org/statistics. Includes federal energy research and development (and excludes demonstration) spending as reported by member countries to the OECD. International comparison only available through 2009.

52. The National Center for Science and the Environment's "Handbook of Federal Funding for Environmental R&D – FY 2011" tallies $9.1 billion in total federal environmental R&D funding in 2010 spread across 11 agencies—a considerable number. The largest sponsor of environment-related R&D is the Department of Energy, whose efforts encompass mainly renewable energy and energy efficiency projects meant to reduce the environmental impact of energy production and consumption, which have been growing swiftly since 2006 but we categorize as energy R&D. Much of the R&D conducted by other significant sponsors like NASA, NOAA, and NSF we consider basic research rather than applied R&D. The subtle distinction here is between invaluable basic research into *how the climate is changing* from NASA and NOAA, and more market-oriented applied research into and development of *technologies that can mitigate change*, for example. This report's focus on the production of goods and services with an environmental purpose aligns closest with EPA's R&D portfolio, though surely spillover benefits accrue from the Department of Defense's efforts to reduce its environmental impact and the Department of Agriculture's water management innovations, for example, as well.

53. Organization for Economic Cooperation and Development iLibrary, "Government Budget Appropriations or Outlays for R&D by Socioeconomic Objective," accessed May 11, 2011 and available at www.oecd-ilibrary.org/statistics. Includes research and development spending with an environmental objective, as reported by countries to the OECD. International comparisons only available through 2009.

54. See Dan Kammen, "The Case for State RD&D Programs," presentation made at the National Governors Association State Workshop on Clean Energy Research, Development, and Demonstration (March 2008).

55. See Jim Duderstadt and others, "Energy Discovery-Innovation Institutes."

56. In August 2009, the DOE established 46 Energy Frontier Research Centers comprising universities, national laboratories, non-profit organizations, and for-profit firms. These Centers were funded at $2-5 million per year for a 5-year initial award period. For more information, see DOE's Energy Frontier Research Centers website at www.er.doe.gov/bes/EFRC/index.html. Modeled after the Department of Defense's Defense Advanced Research Projects Agency (DARPA), the DOE's ARPA-E program was created by H.R. 364 in 2007 but only allocated a budget of $400 million in April 2009 through ARRA. Like DARPA, ARPA-E identifies game changing ideas and funds them. At least six ARPA-E projects, ranging from solar and wind to advanced batteries have gone on to win additional backing from venture capitalists. For more details, see www.arpa-e.energy.gov/. In FY 2010 budget, DOE requested financing for Energy Innovation Hubs in eight areas: smart grid, solar electricity, carbon capture and storage, extreme materials, batteries and energy storage, energy efficiency buildings, nuclear energy, and fuels from sunlight. Thus far, three hubs have been launched: the Energy-Efficient Buildings System Design Hub run by the Greater Philadelphia Innovation Cluster (GPIC), led by Penn State University; the Fuels from Sunlight Energy Innovation Hub run by the Joint Center for Artificial Photosynthesis, led by Caltech; and the Nuclear Energy Modeling and Simulation Energy Innovation Hub run by the Oak Ridge National Laboratory. For details, see www.energy.gov/hubs/index.htm.

57. For general information on the WITC, visit www.epa.gov/wtic/index.html. See also "Administrator Jackson, SBA Administrator Mills Announce launch of Water Technology Innovation Cluster" (U.S. Environmental Protection Agency Press Release, January 18, 2011).

58. See www.eesi.org/fy-2011-budget-compromise-cuts-funding-environmental-energy-programs-19-apr-2011.

59. The Obama administration's FY 2012 budget request includes $100 million to continue supporting the 46 Energy Frontier Research Centers; $550 million for ARPA-E; and $146 million to support the three existing Energy Innovation Hubs and to establish three new Hubs in the areas of batteries and energy storage, smart grid technologies and systems, and critical materials. See www.energy.gov/news/10064.htm.

60. For information on the Clean Energy Innovation Consortia proposal see www.energyinnovationconsortia.org/.

61. For the concept of a Water Innovation Center, see G. Allen Burton and others, "Leveraging the Great Lakes Region's Water Assets for Economic Growth" (Washington: Brookings Institution, 2010).

62. For discussion of these and other revenue ideas see Hayward and others, "Post Partisan Power" and the President's Council of Advisors on Science and Technology, "Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy" (Washington: 2010). See also Hundt and Mann, "Rebuild American Infrastructure?" and Zoli and Rothstein, "Repatriation to Accelerate Clean Energy."

63. For background on state efforts in clean energy RD&D, see Daniel Kammen, "Opportunities for States in Clean Energy Research, Development & Demonstration," (National Governors Association, 2008). This report identified nine states as having dedicated clean energy RD&D funds: California, Connecticut, Florida, Illinois, Massachusetts, Minnesota, New Jersey, New York, and Wisconsin. See also Escobar and Gander, "Clean and Secure State Energy Actions," which lists state-by-state actions on clean energy RD&D between July 2008 and May 2010. State efforts in clean energy RD&D can be broadly categorized under direct investment in research; supporting incubators; establishing seed funds to bridge funding gap between lab research and venture funding; and supporting demonstration projects. States' direct investment in research is mostly achieved through the creation and funding of research centers within state universities. Examples include the Florida Solar Energy Research Center, Oregon's Built Environment & Sustainable Technologies Center (BEST), South Dakota's 2010 Research Centers, and Virginia's Coastal Energy Research Consortium (VCERC). States also provide support to cleantech incubators that provide guidance, technical assistance, and consultation to companies to help them develop and commercialize clean technologies. Examples of this include the Colorado Collaboratory and NYSERDA's Clean Energy Business Incubator program. Moving along the cleantech RD&D continuum, states also provide seed funds to help companies develop and commercialize their products and services. Some state examples are: Iowa Power Fund supporting research, development, commercialization, and deployment of biofuels, renewable energy technologies, and energy efficiency technologies; MassCEC's Investments in the Advancement of Technology program that makes venture capital equity investments in promising early-stage clean energy companies that are developing and commercializing technologies; and the Edison Innovation Clean Energy Fund that helps New Jersey companies in demonstration projects and developmental and ancillary activities necessary to commercialize energy efficiency and renewable energy technologies. Typical state awards in this category can range anywhere from $100,000 up to $500,000. Finally, some states can maintain dedicated grants and awards supporting demonstration projects. These include the Connecticut Clean Energy Fund's Operational Demonstration Program; the Delaware Green Energy Fund's Technology and Demonstration Program; Massachusetts' Catalyst Program; and South Carolina's Renewable Energy Grant program, which provides matching grants for demonstration projects. Awards for demonstration projects can range from $40,000, as in the Massachusetts example, to $500,000, as in the Connecticut example.

64. For background on the state clean energy funds, see Lewis Milford and others, "Clean Energy and Economic Development: How Existing and New State Clean Energy Funds Could Become the Engines of Job Growth, Industry Creation, and Exports" (Washington: Brookings Institution, forthcoming).

65. Deutsche Bank Climate Change Advisors, in a similar discussion, argues that "`TLC'—transparency, longevity, and certainty—drives investment." They say: "Investors need transparency in policies to create understanding and a level playing field. Longevity means policy has to match the timeframe of the investment and stay the course. Certainty refers to knowing that incentives are financeable and can be trusted in the financial return calculation and again are likely to be maintained over the course of the investment. TLC should result in a lower cost of capital for projects while still delivering a fair and market-related return to capital." See DBCCA, "Investing in Climate Change 2011."

66. They do this by facilitating dense knowledge flows, the sharing of vital resources, and the matching of specialized workers to firms. In one influential discussion, the urban economist Gilles Duranton has identified three mechanisms by which clusters work: learning, sharing, and matching. Learning is facilitated in clusters as workers share knowledge with one another, switch firms, or create start-ups after leaving an older firm. Clustered firms share a number of potentially vital resources like specialized suppliers or clients, organizations (e.g. university departments, research organizations, grant-making foundations), infrastructure (e.g. roads, ports, and even office buildings), labor, training programs, and a favorable policy environment. Finally, in a clustered environment, it is easier for workers to match their specialized skills with the right firm or vice versa. See Gilles Duranton, Philippe Martin, Thierry Mayer, and Florian Mayneris, *The Economics of Clusters: Evidence from France* (Oxford: Oxford University Press, 2010).

67. For more extensive discussion of the significance of regional industry clusters see, among other literature, Mark Muro and Bruce Katz, "The New `Cluster Moment:' How Regional Innovation Clusters Can Foster the Next Economy" (Washington: Brookings Institution, 2010).

68. For a discussion of the nature and economic importance of regional industry clusters see Muro and Katz, "The New `Cluster Moment.'"

69. For a review of recent federal cluster offerings see Muro and Katz, "The New `Cluster Moment.'" Note that "clean" and "green" initiatives have figured among the winners of several of these initial offerings. Three of the 10 "Innovation Economies" that received SBA Regional Cluster Initiative pilot grants last fall involved clean industries. These ranged from the Carolinas' nuclear cluster to Connecticut's hydrogen fuel cell coalition and the Illinois Smart Grid cluster. Likewise, the Oregon Built Environment and Sustainable Technologies Center is a partner in one of the six consortia that won EDA's i6 Challenge.

70. For information on the Energy Regional Innovation Cluster for efficient buildings systems, see www.energy.gov/hubs/eric.htm. For information on the i6 Green Challenge, see www.energy.gov/news/10169.htm.

71. For information on various cluster- or region-focused state clean economy development initiatives, see the following websites: Colorado: www.coloradocollaboratory.org/; New York: www.nyserda.org/publications/2010_Strategic_Plan.pdf; Oregon: www.oregonbusinessplan.org/Industry-Clusters/About-Oregons-Industry-Clusters.aspx.

72. In FY 2010 the EDA, SBA, and USDA made available less than $150 million in small grants for regional innovation clusters programming. In that year, the EDA received 83 applications for grants under the i6 Challenge and made six awards. This spring, the agency had by early May received 140 letters of intent to apply for the i6 Green Challenge, which will also make just six awards. Correspondence with John Fernandez, EDA administrator, April 29, 2011 and May 2, 2011.

73. Duderstadt and others, "Energy Discovery-Innovation Institutes."

74. For a view of these matters across multiple sectors see Mark Muro and Kenan Fikri, "Job Creation on a Budget: How Regional Industry Clusters Can Add Jobs, Bolster Entrepreneurship, and Spark Innovation" (Washington: Brookings Institution, 2011).

75. One-third of the current 400,000 jobs in the electric power industry will become vacant by 2013, following a wave of baby boomer retirements, and will need to be replaced with well-trained workers skilled in various clean energy technology operation. See the National Commission on Energy Policy, "Task Force on America's Future Energy Jobs" (Washington: October 2009). A Lawrence Berkeley National Laboratory report projects a two- to four-fold increase in the size of the energy efficiency sector between 2008-2020, with workforce need reaching a 220,000 person-year equivalent (PYE) in a low growth scenario to a 380,000 PYE in a high growth scenario in 2020. See Charles Goldman, Jane Peters, Nathaniel Albers, Elizabeth Stuart, and Merrian Fuller, "Energy Efficiency Services Sector: Workforce Education and Training Needs" (Berkeley Lawrence Berkeley National Laboratory, 2010). The American Solar Energy Society estimates that renewable energy and energy efficiency sectors combined would grow from 9 million in 2007 to 16.3 million jobs by 2030, assuming no new federal-level clean energy policy initiatives. See Roger Bezdek, "Green Collar Jobs in the U.S. and Colorado: Economic Drivers for the 21st Century" (Boulder: American Solar Energy Society, 2008).

76. See Michael Fletcher, "Retrained for Green Jobs, but still waiting on work." *The Washington Post*, November 22, 2010. See also, Abby Gruen, "NJ Green Jobs Creation Slow, Despite Grants." *The Newark Star-Ledger*, April 7, 2010. According to a recent state-backed University of California, Berkeley report, California's job market in the energy efficiency sector will remain tight through 2020 and, rather than funding training programs for new workers, the focus should be on upgrading the energy efficiency skills and knowledge of the incumbent workforce. See Carol Zabin and others., "California Workforce Education & Training Needs Assessment" (Donald Vial Center on Employment in the Green Economy, University of California, Berkeley, 2011). The concerns about "too many workers, too few jobs" seem especially troublesome in the backdrop of significant infusion of ARRA dollars for purpose of job training and preparing workers for careers in clean economy. Through ARRA, the Department of Labor has allotted $500 million, across five categories, for clean energy workforce training. The Department of Energy has provided up to $100 million for smart grid workforce training. In addition, many states are also using portions of their State Energy Program and Weatherization Assistance Program funding for clean energy workforce training. For more details, see Devashree Saha, "Enhancing State Clean Energy Workforce Training to Meet Demand" (Washington: National Governor's Association Center for Best Practices, 2010).

77. See, for example, National Commission on Energy Policy, "Task Force on America's Future Energy Jobs" and Saha, "Enhancing State Clean Energy Workforce Training to Meet Demand."

78. For background on the "regional innovation program' included in the AmericaCOMPETES reauthorization act last year, see Mark Muro, "AmericaCOMPETES: Pass It, Nevertheless." The Avenue, a blog of *The New Republic*, December 21, 2010.

79. For broader discussions of the regional or metropolitan focus of the U.S. economy, see Bruce Katz, Jennifer Bradley, and Amy Liu, "Delivering the Next Economy: The States Step Up" (Washington: Brookings Institution, 2010) and Bruce Katz and Jennifer Bradley, "Metro Connection." Democracy 20, Spring 2011.

80. For more comprehensive discussions of federal, state, and regional cluster dynamics and policy see Muro and Katz, "The New `Cluster Moment,'" and Muro and Fikri, "Job Creation on Budget."

81. Muro and Fikri, "Job Creation on Budget" outlines one possible design for a competitive state cluster grant program.

82. All of the discussion of the regional analysis and coordination agenda draws heavily on Muro and Katz, "The New `Cluster Moment.'"

83. Puget Sound Regional Council and Brookings Institution, "Innovation Meets Demonstration: A Prospectus for Catalyzing Growth in Puget Sound's Energy Efficiency Technology Cluster" (Washington, 2011).

84. See the Climate Prosperity Project, Inc. at www.climateprosperityproject.org/pilot_regions.htm.

85. Depending on the region, clean economy development activities may be facilitated or led by entities as varied as a regional economic development entity, a metropolitan planning organization, a university or consortia of universities, a formal cluster organization, or trade association.

86. For an overview of Climate Prosperity's activities in the four metro regions, see www.climateprosperityproject.org/.

87. For an overview of Syracuse Tech Garden's activities, see www.thetechgarden.com/cleantech.

88. For an overview of Milwaukee Water Council's activities, see www.thewatercouncil.com/.

89. For an overview of CleanTECH San Diego's activities, see www.cleantechsandiego.org/.

90. See, for instance, Zabin and others., "California Workforce Education & Training Needs Assessment."

91. See the Institute for Sustainable Communities' Case Study on "Los Angeles Trade-Technical College: A Model of Workforce Development in the Energy/Utility Sector" (May 2010). In a more rural setting the Renewable Energy Technology Program at Columbia Gorge Community College in Oregon emerged out of a dialogue with the private sector after wind manufacturers began opening wind farms in the region and seeking trained workers. For more details see SEED Center, "Columbia Gorge Community College Leads Nation in Wind Training," available at www.theseedcenter.org/Colleges-in-Action/Success-Stories/Columbia-Gorge-Community-College-Leads-Nation-in-W.

92. See the Institute for Sustainable Communities' Case Study on "Going to the Source: Seattle Turns to Employers on Green Job Potential and Job Training" (April 2010).

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