In Brief:

Clean Energy Markets: Jobs and Opportunities

April 2010 Update

Executive Summary

This brief discusses how investment in clean energy technologies will generate economic growth and create new jobs in the United States and around the globe. The United States stands to benefit from the expansion of global clean energy markets, but only if it moves quickly to support domestic demand for and production of clean energy technologies through well-designed policy that enhances the competitiveness of U.S. firms.

Clean energy markets are already substantial in scope and growing fast. Between 2004 and 2007, global investments in renewable energy more than doubled. Forecasts of investment totals over the next few decades vary according to assumptions made regarding the nature of future global climate agreements. Annual investments in global renewable energy markets could reach $106-$230 billion a year in 2020 and as much as $424 billion a year in 2030 (in year 2000 dollars). Over the next decade, assuming strong global action on climate change, cumulative global investment totals for clean power generation technologies could reach nearly $2.2 trillion.

Recognizing the potential of these markets, China, Europe, and other nations are moving to cultivate their own clean energy industries and position them to gain large market shares in the decades ahead.

- In 2009, China invested more money in clean energy technologies than the United States for the first time, and Europe continued to lead the world in clean energy investments, spending over $41 billion. Nearly 90 percent of today's market for clean energy technologies is outside of the United States, primarily in Asia and Europe.
- China now boasts the world's largest solar panel manufacturing industry – which exports about 95 percent of its production to countries including the United States.
- Danish wind manufacturers produce close to 40 percent of annual global installed wind capacity.
- German companies could capture 15-20 percent of several global clean energy markets by 2020.

These countries have taken deliberate steps to position themselves as leaders in the 21st century clean energy economy. History shows that it matters where industries are first established, and countries can use policy to foster domestic "lead markets" for particular industries, giving them the foothold that can lead to significant growth in global market share. In the United States, well-crafted climate and clean energy policy can give nascent clean energy industries such a foothold by creating domestic demand and spurring investment and innovation. Strong domestic demand creates not only export opportunities but also jobs – many of which must be located where the demand is, thus fostering domestic job growth even when industry supply chains are globally dispersed. Many studies indicate that clean energy industries generate more jobs per unit of energy delivered than conventional fossil fuel industries.

Ultimately, comprehensive climate and energy policy in the United States can help create jobs and domestic early-mover industries with the potential to become major international exporters. Such policy should include a mechanism, such as a cap-and-trade system or other market-based approach, that puts a price on carbon and provides incentives for investment in clean energy. The time to act is now: through policy leadership at home and abroad, the United States can position itself to become a market leader in the industries of the 21st century.

Introduction

As Congress works to craft comprehensive climate and clean energy legislation, one key question is how such a policy might affect the ability of U.S. firms to compete in international markets. Although some raise concerns that comprehensive policy will put certain U.S. industries at a competitive disadvantage in international markets if other major economies do not adopt similar carbon constraints, recent research indicates that these potential impacts are modest and can be addressed through well-designed policies.[1] Less attention has been paid to the opportunity presented by climate and clean energy policy to enhance the competitiveness of U.S. firms by driving innovation in the high-growth industries of the future.[2] Failure to adopt such policy will ultimately hurt the ability of U.S. companies to compete in emerging, and potentially lucrative, clean energy technology markets—both here and abroad. These markets include products related to renewable energy sources such as wind, solar, biomass, geothermal, and hydropower; carbon capture and storage (CCS) technologies; nuclear power; advanced fuels and vehicles; and industrial, transportation, and building energy efficiency technologies. Anticipating growing demand for these technologies both at home and abroad, other nations are moving to cultivate strong clean energy industries. The United States stands to benefit from economic and employment growth in this clean energy future if it adopts climate and energy policy that stimulates domestic investment in these technologies.[3] This brief examines the state of the emerging clean energy technology market, the actions other countries are taking, and the policies that would better position U.S. firms as market leaders.

A Global Opportunity

Countries do not compete with one another in the same zero-sum manner that companies do. Rather, since countries provide markets for one another's products, economic growth abroad means bigger markets into which U.S. companies can sell.[4] The growth of the global economy over time creates new economic opportunities for all nations.

The implication for climate and clean energy policy is that it is not just the size of the U.S. clean energy market that matters – though this is important – but the size of the overall global market as well. Global clean energy markets are expanding as a function of several factors, such as efforts to reduce GHG emissions in light of growing worldwide concern over climate change; an increased desire on the part of many countries to achieve greater energy security and become less reliant on fossil fuels; higher fossil fuel prices as energy demand grows around the world; and the need to address other environmental problems, such as regional air pollution and water quality.[5] Action to address these concerns effectively expands the size of new clean energy markets, providing opportunities for all businesses – and the more action taken around the globe, the greater the scope of these potential opportunities.

Thus, everyone – including the United States – benefits from China, Europe, and other regions moving on climate and clean energy technology policy, if they are positioned to effectively compete in the expanding clean energy markets of the 21st century. However, U.S. firms are currently lagging behind their foreign competitors and missing opportunities to compete in these markets. Spurred by national and international actions, including an eventual international climate agreement, clean energy

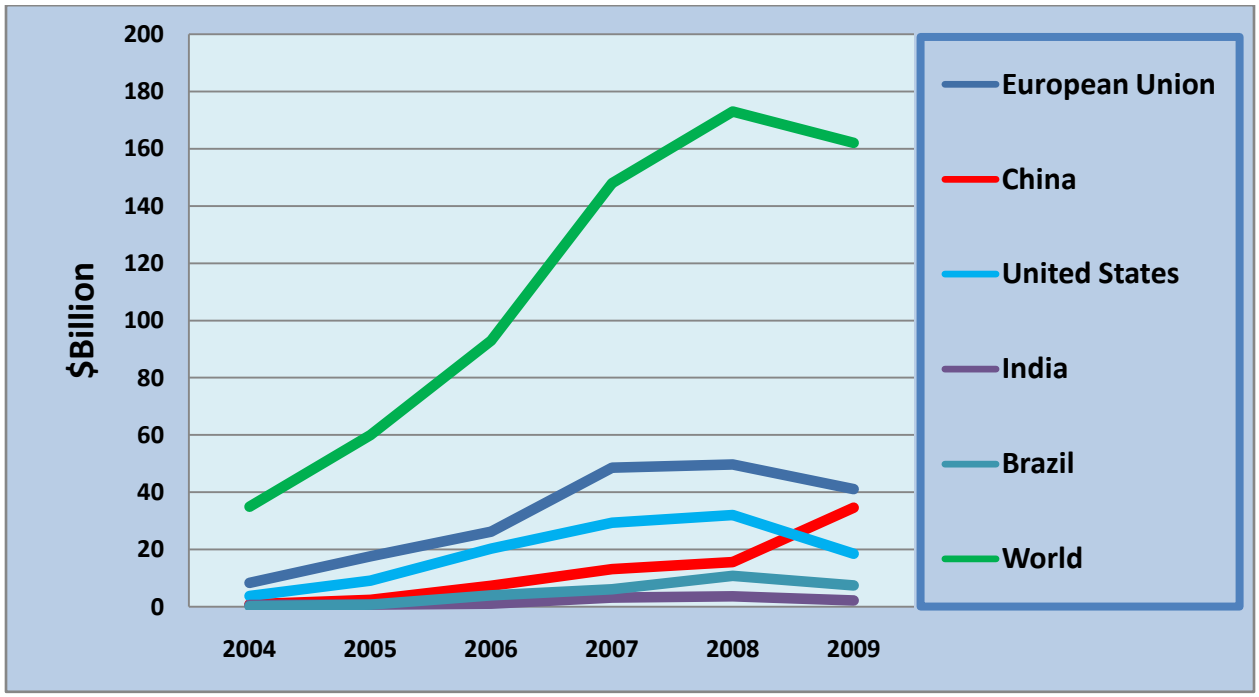
technology markets are poised to play an increasingly important role in the decades ahead as their growth opens up new business opportunities. Domestic policy can help bolster the ability of U.S. industries to sell into these substantial new markets, and U.S. leadership in the international climate negotiations can affect the scope of the global market.

Current Status of Clean Energy Markets and Future Outlook

Clean energy technology markets are already substantial in scope and likely to grow significantly in the coming decades. This is especially true should the United States adopt climate and energy legislation, but, driven by the range of concerns noted above, worldwide demand for lower-carbon technologies is increasing even in the absence of U.S. action.

Between 2004 and 2009, clean energy investments (including renewables, efficiency technologies, biofuels, CCS, nuclear power, and other low-carbon technologies) grew at an average compound annual growth rate (CAGR) of 39 percent (see Figure 1) and the wind and solar markets have sustained annual growth rates above 30 percent for the last decade.[6]

Figure 1: Global New Investment in Clean Energy Technologies, 2004-2009



From 2004-2009, global cleantech investment averaged a CAGR of 39 percent, reaching $173 billion in 2008. This figure includes renewables, efficiency technologies, biofuels, CCS, nuclear power, and other low-carbon technologies. As this figure illustrates, for the first time China invested more in clean energy technologies than the United States in 2009.
Sources: United Nations Environment Program and New Energy Finance, "Global Trends in Sustainable Energy Investment 2009: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency," 2009 and "Clean Energy League Tables." Bloomberg New Energy Finance, March 2010 and Pew Charitable Trusts. "Who's Winning the Clean Energy Race?" Pew Charitable Trusts, 2010.

Global investment in clean energy technologies totaled $173 billion in 2008, with wind, solar, and biofuels accounting for the vast majority of new investment.[7] As in many markets, investment fell in 2009 due to the global recession, decreasing 53 percent in the first quarter of 2009 relative to the same period in 2008.[8] However, clean energy markets have proved remarkably resilient and are expected to return to rapid growth rates; in fact, despite the recession, investment only fell 6.6 percent to $162 billion in 2009.[9] Additionally, stimulus spending in response to the global recession was utilized by some governments to jump start a transition to clean energy technologies and infrastructure, and may push global investment to $200 billion in 2010.[10,11]

The renewable energy sector (including solar, wind, biomass, geothermal, and marine and small hydropower projects) has seen tremendous growth within the past few years. Between 2004 and 2007, global investments in renewable energy more than doubled.[12] The International Energy Agency (IEA) estimates that year-on-year growth in new-build renewable energy assets was 85 percent in 2007.[13] If large hydropower is included, 2008 was the first year in which renewable power generation attracted more investment than traditional fossil fuel generation ($140 billion and $110 billion, respectively).[14] Despite the recession, America added a record 9,900 megawatts (MW) of wind power generation capacity in 2009, increasing its total wind capacity by 39 percent.[15]

Other low-carbon sectors are also substantial in scope. In the nuclear power sector, about 54 reactors are under construction around the world; assuming a typical reactor cost of about $5 billion, this amounts to a current investment total of $270 billion.[16] While global investment totals in building and energy efficiency measures are less certain, 2008 levels of investment in the United States were about $10-12.5 billion.[17] The economic stimulus packages being implemented by governments around the world dedicate a combined total of $62 billion to energy efficiency, and a further $48.7 billion to electric grid development.[18]

Potential market sizes for these and other low-carbon energy sources are considerable, and likely to continue growing given general global trends towards low-carbon technologies.

- Even under a "business-as-usual" (BAU) case that assumes no changes to existing climate change policy by any major emitters, the IEA estimates that cumulative global investments in clean power generation technologies between 2010 and 2020 will total about $1.58 trillion, and will be even larger in the following decade (Table 1).[19]

Table 1: Cumulative Global Investment By Decade, Renewables, CCS, and Nuclear (trillions of $)

	2010-2020	2021-2030	Total 2010-2030
BAU	1.58	1.75	3.33
Strong global action	2.19	4.40	6.59
% change (Strong Action vs. BAU)	+39%	+151%	+98%

"BAU" case assumes no significant changes to existing climate and energy policies around the world. Strong global action assumes the implementation of an international agreement sufficient to limit global average temperature rise to no more than 2° Celsius over the next century – which requires stabilizing atmospheric concentrations of CO_2e at about 450 parts per million (ppm). Since these cases represent two fairly extreme outcomes, actual totals are likely to fall somewhere in the middle of those estimated here – but will be substantial.
Source: International Energy Agency, "World Energy Outlook 2009," 2009.

- Annual investments in global renewable energy markets (including wind, solar, geothermal, hydropower, and biomass) could reach $106-$230 billion a year in 2020 and as much as $424 billion a year in 2030 (in year 2000 dollars).[20] The IEA predicts global cumulative investment in biofuels to be about $163 billion over the next two decades.

Regardless of the course taken by the United States, action by other countries to reduce GHG emissions and transition to clean energy technologies guarantee clean energy markets will continue expanding. Thanks in part to government stimulus packages, global clean energy investments could total $200 billion in 2010.[21] Strong U.S. action and further actions by other nations (including further advances internationally) would make clean energy markets even larger in the long term.

- Under a scenario assuming aggressive international action,[22] from 2010 through 2020 the IEA predicts a cumulative investment total of as much as $350 billion in clean power generation technologies in the United States alone; globally, this cumulative investment figure is nearly $2.2 trillion.[23] Between 2010 and 2030, projected global investment in biofuels is nearly $570 billion, and investments in advanced automobiles are expected to be $3.3 trillion higher than under a business-as-usual case.[24]

- To ensure GHG emissions peak no later than 2020, the United Nations Environment Program and New Energy Finance estimate that clean energy technology investments would need to reach $500 billion a year by 2020.[25] This includes reaching annual investment levels of at least $305 billion in renewables, $40 billion in biofuels, and $5 billion in CCS by 2020.[26]

Perhaps the largest near-term market potential exists in energy efficiency.

- McKinsey and Co. estimate modest action to reduce U.S. GHG emissions could drive investment in residential and commercial building and appliance efficiency alone to a cumulative total of $160 billion by 2030; [27] they also estimate that pursuing the full range of energy efficiency opportunities available in the United States between now and 2020 could require investments of $50 billion a year (compared to 2008 levels of investment of about $10-12.5 billion).[28]

- Under the IEA's aggressive global action scenario, cumulative global investment in residential and commercial building efficiency between 2010 and 2030 is $2.5 trillion more than it would be under a business-as-usual case.[29] In the United States, this equates to additional investments in building efficiency of about $11 billion a year from 2010 through 2020.

The United States has already fallen behind in these emerging markets. According to analysts at New Energy Finance, in 2009 Asia as whole (led largely by Chinese spending on wind projects) invested more money in clean energy technologies than the Americas, and China itself invested $34.6 billion compared to the United States' $18.6 billion (Table 2).[30] Nearly 90 percent of today's market for clean energy technologies is outside of the United States, primarily in Asia and Europe.[31]

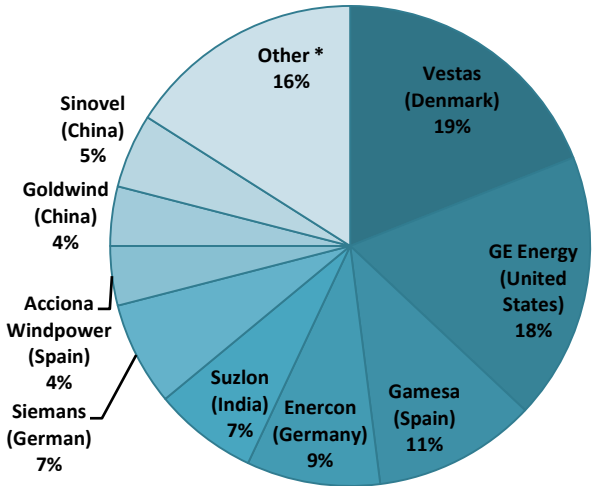
Table 2: Clean Energy Investment by Country/Region	
Country or Region	**2009 Clean Energy Technology Investment ($Billions)**
European Union	41.1
China	34.6
United States	18.6
United Kingdom	11.2
Spain	10.4
Brazil	7.4
Germany	4.3

Source: Pew Charitable Trusts, 2010.

Recognizing the opportunities represented by emerging clean energy markets, other nations – most notably China – are aggressively expanding their own domestic clean energy markets along with the manufacturing capacity to meet anticipated international demand in industries including wind and solar power, advanced batteries, carbon capture and storage, and nuclear energy.

U.S. firms face serious competition in the wind and solar power sectors specifically. In 2008, General Electric had an 18 percent share of the global installed wind turbine market, and 43 percent of the domestic market. However, as shown in Figure 2, of the top five largest wind turbine manufacturers globally, GE is the only U.S. company.[32] The Danish company Vestas remains the top global manufacturer, and the rest of the top five is rounded out by firms in Spain, Germany, and China. The story is similar in other industries; only one of the top 10 solar panel manufacturers is American, as are only two of the top 10 advanced battery manufacturers.[33]

Figure 2: 2008 Installed Megawatt Wind Turbine Market Share



*Includes Nordex, REpower, Mitsubishi, Alstom Ecotecnia, Dongfang, Furhlander, Windey, Clipper, WinWinD, DeWind, Multibrid, and Windflow. None of these companies had more than a 4 percent market share.
Source: Environmental Leader: Energy and Environmental News for Business and Emerging Energy Research.

Taking the Lead: The Benefits of Being an Early Mover

A major reason other countries are moving so decisively on clean energy policy is that they realize the benefits of being an early mover in these new industries. Many factors provide different countries a comparative advantage in the production of some goods relative to others, and an industry may take hold and flourish in a particular region for a number of reasons.[34] For example, economies of scale and geographic spillovers may lead to cheaper production in certain industries within a given country, as similar firms cluster together, leading to cross-pollination of ideas and innovative practices, and further clustering.[35] Aircraft manufacturing in Seattle, information technology in Silicon Valley, and automobile manufacturing in Detroit provide examples of industries that have substantial economies of scale and cluster benefits. In these cases initial growth in certain regions was self-reinforcing and those regions became major centers of activity as the industries expanded dramatically.[36]

This means that it really matters where industries are first established. Countries can adopt policies to foster domestic demand and create "lead markets" for particular industries, giving them an initial foothold that can lead to significant growth and the ability to better compete in global markets.[37] In the case of clean energy markets, well-crafted climate and energy policies can give nascent clean energy industries such a foothold. If these industries take root in the United States first, U.S. firms could become the first to achieve economies of scale and form geographic clusters with spillover benefits, thus achieving the comparative advantage that can ultimately make them the dominant suppliers of clean energy technologies.

A number of countries are taking steps to reduce GHG emissions, become more energy independent, support lead markets for clean energy technologies, and build up their manufacturing capacity to meet expanded domestic and international demand:

- ***China's*** national strategy for addressing climate change includes plans to reduce its CO_2 emissions intensity per unit of GDP by 40 to 45 percent below 2005 levels by 2020 and calls for 15 percent of its primary energy consumption to come from non-fossil fuel sources by 2020.[38] To help meet these goals, China is rapidly accelerating its development of clean energy technologies through heavy investment and by creating incentives that allow these technologies to better compete with incumbent energy sources.[39] The Chinese government has announced a ten-year, $400 billion clean energy technology investment program.[40] To help drive economies of scale and achieve cluster benefits in renewable energy industries, China is using regulatory incentives in an attempt to spur innovation and lower prices; it has announced the creation of "low-carbon centers" that will be established as regional hubs of clean energy technology manufacturing.[41] To make renewables more cost-competitive, China also adds a small surcharge to all consumer electricity bills, estimated to raise residential electricity bills by only 0.25-0.4 percent and industrial bills by 0.8 percent. Revenue raised from this fee is used to offset the difference in cost between renewables and cheaper incumbent power generation (primarily coal).[42] Through these and other subsidies – including a solar power subsidy of $3 per watt – China is also establishing a lead market for solar photovoltaics, initiating the cycle of market creation, investment, and innovation that can lead to strong growth.[43] In an effort to ensure that its domestic production supplies its own market, China has historically restricted imports of solar panels and wind turbines, though these regulations are being relaxed.[44,45] Thanks to these and other incentives, China is now home to the world's largest solar panel manufacturing industry – which exports about 95 percent of its production to countries including the United States.[46] China now also manufacturers more wind turbines than any other country,[47] and its wind power capacity has doubled every year since 2005, giving it about 10 percent of global installed capacity.[48] The Chinese Renewable Energy Industries Association estimates that China's renewable energy industries employed 1.12 million workers in 2008 and are adding 100,000 jobs a year.[49]

- ***The European Union (EU)*** has pledged to reduce its GHG emissions 20 percent below 1990 levels by 2020, and 30 percent below 1990 levels if other developed countries agree to comparable reductions and advanced developing countries contribute according to their capabilities and

responsibilities.[50] The EU's core policy instrument for meeting this target is its emissions trading system (ETS), which sets a mandatory cap on aggregate CO_2 emissions limits for 12,000 installations in six major industrial sectors, with emissions trading.[51] The result is a price on carbon that helps drive investment in clean energy industries. The EU also has a mandatory target of deriving 20 percent its energy mix from renewable sources by 2020. Together, these policies provide strong incentives for investment in clean energy industries in the EU; Europe led the world in clean energy investments in 2008 with $49.7 billion, and is estimated to have led the world again in 2009 with $41 billion.[52]

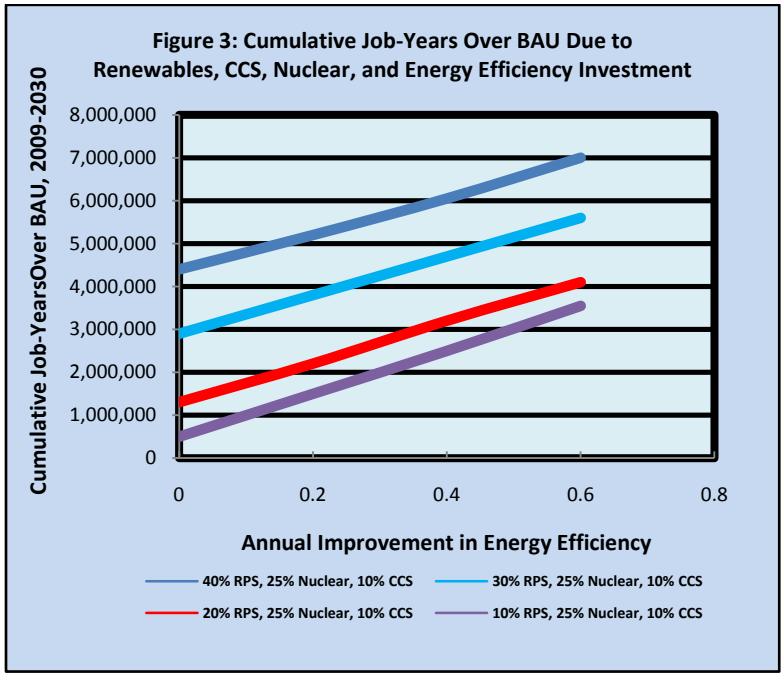
- ***Denmark*** deliberately set out to make itself more energy independent and less reliant on fossil fuels by creating a lead market for wind power. Starting in 1979, the Danish government paid for nearly a third of wind investment costs for a decade, provided loan guarantees for turbine export projects, established utility purchase mandates (i.e., feed-in tariffs) for wind power, and funded research aimed at making turbine production more cost-effective.[53] These policies have given Denmark a share of the global wind turbine market disproportionate to its domestic market and the size of its economy. Twenty percent of Denmark's domestic electricity generation comes from wind, and the largest wind manufacturer in the world – Vestas, which in 2008 had a global installed turbine market share of 19 percent –is Danish. Overall, Danish wind manufacturers produce close to 40 percent of annual global installed wind capacity.[54] Overall, Denmark's energy efficiency and renewable energy policies have helped keep its energy consumption stable even as its GDP has grown 56 percent since 1980.[55]

- ***Germany*** has some of the most ambitious renewable energy and climate policies in the world, including a target of generating 30 percent of its electricity from renewable energy sources by 2020, feed-in tariffs for renewable energy, and a GHG emissions reduction target of 40 percent below 1990 levels by 2020.[56] These policies are already producing significant economic and environmental benefits. Over 15 percent of Germany's gross electricity consumption already comes from renewable energy sources, reducing CO_2 emissions by 15 percent below business-as-usual levels, and Germany produces more electricity from solar photovoltaics than any other nation.[57] Germany is also producing a new generation of highly-skilled architects and engineers; it has won the U.S. Department of Energy's (DOE) biennial Solar Decathlon competition – in which teams of college and university students from around the world compete to build the most attractive and efficient solar-powered house – twice in a row.[58] The German government estimates that, as of 2008, its renewable energy sector accounts for about 280,000 jobs (primarily in the wind, biomass, and solar power sectors) up from 160,000 in 2004; about two-thirds of these jobs are attributed to the effects of Germany's renewable energy policies.[59] By 2020, Germany's renewable energy sector is projected to employ about 400,000 workers.[60] The German government estimates its renewable energy policies have been net job creators and that they will result in a net positive employment effect of over 70,000 jobs by 2020 and 80,000 jobs by 2030.[61] Overall, Germany has become a leader in clean energy manufacturing and positioned its industries to become major exporters in global clean energy markets. If worldwide growth in these markets remains strong, investments in German-made renewable electricity-generating systems could be in the range of $18 billion to over $27 billion a year by 2020, with about $15 billion coming from exports, and German companies could capture 15-20 percent of

several global markets, particularly in component manufacturing for solar energy systems, wind turbines, and hydropower and biomass plants.[62]

- ***South Korea*** is investing approximately 2 percent of its GDP (nearly $17 billion a year) in renewable energy, advanced lighting and smart grid technologies, and hybrid vehicles – investments the South Korean government claims will create about 1.5 million jobs.[63,64] South Korea aims to reduce its GHG emissions 30 percent below business-as-usual levels by 2020.[65]

These are just a few examples of the policies different countries and regions are using to foster domestic clean energy technology industries and the jobs they create.



Using a model derived from 15 other analyses of the economic and employment impacts of clean energy industries, researchers concluded that clean energy industries generate more jobs per unit of energy delivered than conventional fossil fuel industries. Figure 3 shows estimated cumulative net job-years created above a business-as-usual (BAU) case between 2009 and 2030 due to various targets for renewable energy, nuclear power, CCS, and energy efficiency (a job-year is one job performed for one year). The figure summarizes several cases assuming that, by 2030, nuclear power accounts for 25 percent of electricity generation while CCS accounts for 10 percent.[66]
Source: Wei, Max and Shana Patadia and Daniel Kammen. "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the U.S.?" University of California, Berkeley, 2009.

Clean Energy Jobs

There is evidence that stronger environmental standards can drive firms to innovate and become more efficient, and that by spawning markets for new technologies, new standards are at least as likely to result in creating jobs in some sectors as to reducing them in others – though the circumstances under which this is true remain a subject of ongoing debate.[67,68]

Regardless of net effects, many clean energy industries create and sustain jobs in a variety of fields, both directly and indirectly: energy and building efficiency projects require electricians, roofers, and construction workers; installing and shipping wind turbine or solar panel components requires drivers, welders, and routine maintenance workers. In fact, research indicates that clean energy industries generate more jobs per unit of energy delivered than conventional fossil fuel industries. Figure 3 summarizes some of the results from a University of California,

Berkeley study that a used a job-creation model based on the results of 15 other economic analyses to estimate the employment impacts associated with a number of clean energy technology scenarios.[69] Several other studies have focused on the job and economic benefits of particular clean energy technologies or practices (Table 3).

Domestic Demand, International Investment, and Jobs

Many of the low-carbon technologies that would be incentivized under climate and clean energy policy – such as solar panels, wind turbines, efficient automobiles and advanced batteries, nuclear power plants, next generation coal plants incorporating CCS, and others – are complex products with many components and extensive value chains that may span several countries. For example, some components of a new wind turbine may be manufactured in China, and others in the United States; likewise, individual parts of a solar panel may be manufactured in several different countries before its final assembly and installation.[77] Within these value chains, many jobs – such as installers, welders, and construction workers – must be located where the demand is and therefore cannot be outsourced overseas.[78] This means that even if a clean energy technology company is based in a foreign country or manufactures some technology components elsewhere, if it sells products in the United States it is very likely to create local jobs and hire American workers – if domestic clean energy technology markets exist. Domestic markets can entice firms in other countries to shift some of their production to the United States, creating additional jobs.

Table 3: Job Creation and Clean Energy Technologies

Technology	Jobs Potential
Carbon Capture and Storage (CCS)[70]	An analysis by the National Commission on Energy Policy estimated that a new 1 GW coal plant with CCS would create about 11,000 direct job-years associated with development and construction and 200 to 500 ongoing operation and maintenance direct jobs.[71] Looking only at the direct jobs related to new plant construction and ongoing operation, a separate analysis concluded that a new coal power plant with CCS might employ 34 percent more workers during plant construction and 24 percent more during ongoing operation than a traditional coal power plant without CCS.[72]
Energy Efficiency	An analysis of the American Clean Energy and Security Act of 2009, as passed by the U.S. House of Representatives, found that the bill's energy efficiency provisions would create more than 600,000 net new jobs.[73] The same study concluded that strengthening the bill's energy efficiency provisions (such as including a stronger energy efficiency standard) could create additional benefits, resulting in more than 1 million net new jobs by 2030.
Nuclear Power	A recent study conducted by the Idaho National Laboratory and Bechtel Power Corporation estimated the jobs impact from the addition of 50,000 megawatts (MW) of new nuclear generating capacity (a roughly 50 percent increase in U.S. nuclear power capacity) brought online over a 15-year period.[74] The study concluded that such an expansion could create a cumulative total of over 600,000 jobs.[75]
Agriculture and Biofuels	One study found that an ethanol plant producing 40 million gallons per year creates $142 million in local economic activity during construction and buys $56 million in goods and services annually, 71 percent of which goes to farmers.[76]

This is already occurring to some extent, both to meet demand in today's relatively small domestic markets and in anticipation of future U.S. climate and clean energy policy:

- Researchers at the Peterson Institute for International Economics have found that the complex, globalized nature of the wind energy industry means that local demand will generate local production and jobs, regardless of where companies are headquartered.[79] For example, Goldwind, a Chinese company, is looking to expand into the U.S. wind power market, a move which will likely require the hiring and training of U.S. workers.[80]

- Nissan, a Japanese car company, recently announced it will open a manufacturing facility in Tennessee to build 150,000 of its new all-electric cars and the lithium-ion batteries used to power them. The U.S. DOE has said it will loan Nissan $1.4 billion to help pay for plant retrofits, and the plant is expected to support 1,300 American jobs.[81]

- Suntech, a Chinese solar power firm and the largest photovoltaics manufacturer in the world, is opening a manufacturing facility in the United States – and hiring American workers – in an effort to expand further into the North American market and take advantage of what it perceives to be good prospects for U.S. solar panel demand.[82]

These examples illustrate how foreign investment can lead to job creation in the United States. However, today's domestic markets remain relatively small, and these levels of investment – and the number of jobs created – could be much larger if domestic demand were greater; while these international firms are hiring American workers, the bulk of their operations remains abroad. Furthermore, these examples underscore the fact that foreign firms are taking the lead in these new industries and meeting domestic demand. Again, climate and energy policy would not only create a substantially larger domestic market, but also stimulate domestic firms to expand their operations at home and hire American workers, better positioning them to sell into both local and international markets.

Some U.S. companies already have an international presence, as they go where demand exists and invest in projects abroad:

- First Solar, Inc., an American company, has entered into an agreement to build a 2,000 MW solar photovoltaic power plant in China – the largest planned project of its kind in the world.[83] While First Solar will also add new manufacturing jobs at its U.S. facilities, at least 71 percent of its planned growth is outside of the United States.[84]

- ESolar, based in Silicon Valley, recently announced it is licensing its solar thermal technology to a Chinese firm which plans to use it to build the largest concentrated solar power plant in China.[85]

- GE has announced plans to work with a Chinese utility to construct next-generation coal plants in China, including at least one plant that captures its carbon dioxide emissions.[86] The new plants will use GE's integrated gasification combined cycle technology, which allows for lower-

emitting coal combustion and makes it easier to capture and sequester GHG emissions from power plants.

A substantially larger domestic market, as would be created under comprehensive climate and clean energy policy, would create more success stories for U.S. companies both at home and abroad.

Seizing the Economic Opportunities: Policies for a Clean Energy Future

Other nations are already demonstrating how climate and clean energy policies can provide an edge in preparing for the clean energy technology markets of the future. It is not too late for the United States to position itself as a leader, but the time to act is now. A number of policies can attract domestic investment in clean energy markets, creating jobs and domestic first-mover industries that will ultimately be better able to compete in global clean energy markets:

- ***Comprehensive National Climate and Energy Policy***: Perhaps the single most important component of domestic climate and energy policy is a mechanism that puts a price on GHG emissions, such as a cap-and-trade system or other type of market-based approach. Such a mechanism can help achieve a given level of GHG reductions as cost-effectively as possible by driving innovation and providing the regulatory certainty needed to spur private sector investment in clean energy technologies.

- ***International Action***: On the international front, it is in the interest of the United States to provide global leadership in the effort to develop an international climate agreement with as broad a scope as possible. Such an agreement is the best means of tackling the global climate change problem, and can also foster a vibrant global market in clean energy technology, with more ambitious and comprehensive agreements creating larger global markets. U.S. leadership is critical to achieving the best possible outcome in the international climate negotiations, and can thus affect the scope of the global market. By enacting domestic policy, the United States can demonstrate the kind of leadership needed to advance an international agreement.

- ***State Action***: U.S. state policy can continue to provide a strong foundation for federal policy going forward. The 31 U.S. states with renewable portfolio standards are stimulating demand for these technologies and promoting local economic development. For example, when Pennsylvania enacted its Alternative Energy Portfolio Standard, the Spanish wind manufacturer Gamesa located its U.S. headquarters in the state, creating jobs. A comprehensive national policy would more efficiently and effectively drive U.S. leadership in clean energy technologies, though states can continue to retain a key role in the implementation of many effective complementary policies, such as renewable energy and energy efficiency standards, building codes, and even zoning laws.

- ***Research and Development***: Research and development (R&D) funding can support innovation and foster lead industries.[87] For example, the information technology and biopharmaceutical

industries spend between 10 and 20 percent of their revenues on R&D, and the biopharmaceutical industry spent nearly $60 billion on R&D in 2007. Similar levels of investment in the energy sector may give clean energy industries the foothold needed to flourish in the United States. The U.S. DOE is already in the process of establishing at least three such research clusters that will focus on basic research into next-generation nuclear reactors, energy efficient buildings, and fuels produced from sunlight, with the goal of bringing new technologies to commercial readiness.[88] DOE also recently announced over $151 million in funding for energy projects through its Advanced Research Projects Agency-Energy (ARPA-E), a relatively new agency within DOE that aims to fund high-risk, high-payoff energy and climate research.[89] A similar program in the Department of Defense, known as DARPA, funded projects that ultimately led to the commercialization of microchips, the Internet, and other technologies. Comprehensive climate and energy policy can provide further support to cutting-edge research efforts; the American Clean Energy and Security Act of 2009 (H.R. 2454), as passed by the U.S. House of Representatives would establish the Clean Energy Deployment Administration (CEDA), an independent corporation owned by the United States and charged with financing domestic development and deployment of clean energy technologies using $7.5 billion in bonds.[90] Clean energy bills under consideration in the U.S. Senate, such as the American Clean Energy Leadership Act of 2009, would establish similar programs.

- ***Targeted Spending***: Direct, targeted government spending that creates demand for clean energy can also help foster domestic industries and jobs in these sectors. The American Recovery and Reinvestment Act of 2009 (Recovery Act or ARRA) – the economic stimulus package enacted in February 2009 – set aside about $63 billion for energy and transportation projects, with an additional $21 billion in tax incentives related to alternative energy.[91] In January 2010, $2.3 billion of the Recovery Act's funds were directed to advanced energy manufacturing tax credits to help support manufacturing projects and jobs in the clean energy sector.[92] Additional funds are being directed to transportation infrastructure projects, including $8 billion awarded to states to help fund over a dozen high-speed rail corridors.[93] The White House Council of Economic Advisors estimates that as of the end of 2009, the clean energy provisions in the ARRA had saved or created 52,000 clean energy jobs and induced another 11,000 jobs throughout the economy, and that by the end of 2012 these provisions will have created more than 700,000 job-years.[94]

- ***Other policies***: Other policies can foster home-grown clean energy industries. For example, federal Production Tax Credits have proven effective at driving investment in renewable energy, but have historically required frequent re-authorization, creating uncertainty for businesses who don't know when the credits might expire. Stabilizing federal Production Tax Credit cycles can help sustain investment and growth in renewables (for example, by putting into place incentive programs with longer periods before required Congressional renewal). Loan guarantees, first authorized under the Energy Policy Act of 2005, with increased amounts recently proposed by the Obama Administration, are jumpstarting a new generation of nuclear power plants.

Conclusion

Action around the world means that global clean energy markets are poised for significant growth in the coming decades. The United States stands to benefit from the development of these markets, but only if it moves quickly to support domestic demand for and production of clean energy technologies. Fostering domestic markets will create jobs and give lead industries the initial foothold they need to ultimately better compete in rapidly expanding international clean energy markets – and the sooner these industries can be established, the larger the share of these global markets they stand to gain in the decades ahead. Through policy leadership at home and abroad, America can position itself as a market leader in creating a clean energy future.

Notes:

[1] Specific concerns exist over potential adverse impacts of climate policy on energy-intensive, trade-exposed (EITE) industries' competitiveness in international markets. However, recent research has found these effects to be modest, and well-designed policies – including free allowance allocation and an eventual international climate agreement – can moderate their impacts and help these industries transition to a low-carbon future. For a more in-depth discussion of the extent of these impacts, see Aldy, Joseph and William Pizer. "The Competitiveness Impacts of Climate Change Mitigation Policies," Pew Center on Global Climate Change, 2009. For more information on the policy options available to help address them, see "Addressing Competitiveness in U.S. Climate Change Policy," Pew Center on Global Climate Change, 2008, and "The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries: An Interagency Report Responding to a Request from Senators Bayh, Specter, Stabenow, McCaskill, and Brown," United States Environmental Protection Agency, December 2009. The Pew Center has also developed a table summarizing the ways in which various climate and energy policy proposals around the world have considered addressing impacts to vulnerable industries, available here.

[2] The theory that environmental regulation can improve industrial competitiveness by forcing firms to continually innovate was originally formulated by the economists Michael Porter and Claas van der Linde, and is often referred to as the Porter Hypothesis. See Porter, Michael and Claas van der Linde. "Toward a New Conception of the Environment-Competitiveness Relationship," Journal of Economic Perspectives, Vol. 9, No. 4, 1995, pp. 97-118. There is an ongoing debate over the circumstances under which this claim may be true; for some critiques of the Porter hypothesis see Ziesemer, Thomas. "The Porter Hypothesis Revisited: An Overview on Empirical and Theoretical Evidence," Papers in Global Business Management, Universität Augsburg, December 2007, and Palmer, Oates, and Portney, "Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm?" J. of Economic Perspectives, 9(4), 1995.

[3] The net impact of climate and clean energy policy on employment is difficult to quantify, as some carbon-intensive jobs will require a transition and others will be lost – even as others in new low-carbon sectors are created. The job creation potential associated with various technologies is discussed further below in this brief.
[4] For a more extended discussion of contemporary international trade theory, see Krugman, Paul. "Making sense of the competitiveness debate (different approaches to the concept of competitiveness," Oxford Review of Economic Policy, 12.n3, Autumn, 1996: pp17(9) and Krugman, Paul. "Competitiveness: A Dangerous Obsession," Foreign Affairs, Volume 73, No. 2, March/April 1994: pp.30-44.
[5] The International Energy Agency (IEA) predicts that under business-as-usual, worldwide primary energy demand will increase 40 percent by 2030 (as compared to 2007), electricity demand will grow 2.5 percent a year for the next two decades, and demand for oil will increase nearly 25 percent to 105 million barrels a day in 2030. The IEA also projects increasing fossil fuel prices. See International Energy Agency, "World Energy Outlook 2009," 2009.
[6] Overall clean energy investment growth estimates are derived using data from United Nations Environment Program (UNEP) and New Energy Finance, "Global Trends in Sustainable Energy Investment 2009: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency," 2009 and Pew Charitable Trusts 2010. This figure includes total financial investment (including venture capital, private equity expansion capital, public markets, and asset finance) as well as government research and development (R&D), corporate R&D, and small projects. Wind and solar market growth estimates are from Makower, Joel and Ron Pernick and Clint Wilder. "Clean Energy Trends 2009," Clean Edge Inc., March 2009.
[7] This total includes investments in renewables, energy efficiency, biofuels, CCS, nuclear power, and other low-carbon technologies. See UNEP and New Energy Finance 2009.
[8] Ibid
[9] "Clean Energy League Tables." Bloomberg New Energy Finance, March 2010.
[10] In its World Energy Outlook 2009, the IEA notes the impact of the financial crisis on overall energy investment, and that it will lead to a temporary reduction in GHG emissions below business-as-usual levels. How the world chooses to structure its economic recovery will have important and far-reaching consequences, and the recession offers a rare opportunity for governments to adopt policies that shift incentives, steer investment to clean energy sources and infrastructure, and prevent a return to carbon-intensive energy investments once global demand picks up.
[11] Pew Charitable Trusts. "Who's Winning the Clean Energy Race?" Pew Charitable Trusts, 2010.
[12] German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, 2008.
[13] International Energy Agency "World Energy Outlook 2009," 2009.
[14] UNEP and Clean Energy Finance, 2009.
[15] Mouawad, Jad. "Wind Power Grows 39% For the Year," The New York Times, January 26th, 2010.
[16] IEA 2009. Notably, none of these plants are being built in the United States, but are principally in China, India, Korea, and Russia. However, since 2007 a number of applications for new nuclear plant licenses have been submitted to the U.S. Nuclear Regulatory Commission and are under review, though most of these plants have yet to obtain financing and are not yet committed to construction. See Nuclear Energy Institute (NEI), Status and Outlook for Nuclear Energy in the United States, May 2009, and MIT, Update of the MIT 2003 Future of Nuclear Power, May 2009.
[17] Granade, H.C. et al. "Unlocking Energy Efficiency in the U.S. Economy," McKinsey and Company, July 2009.
[18] UNEP and Clean Energy Finance 2009, and "Accelerating Technological Innovation in Energy," Presentation by Bill Bonvillian, Director, Massachusetts Institute of Technology Washington D.C. office, to the Canadian Embassy, October 15th, 2009.
[19] IEA 2009. Unless otherwise noted, all IEA investment figures are in 2008 dollars. Clean power generation technologies includes renewables, CCS, and nuclear power. Cumulative totals for each of these categories in the decade 2010-2020 are $1.25 trillion, $2 billion, and $297 billion, respectively. As noted, investments in the following decade (2021-2030) are significantly higher; for example, cumulative investment in CCS could be $43 billion in those years.
[20] German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety. "Renewable Energy: Employment Effects: Impact of the Expansion of Renewable Energy on the German Labour Market," June 2006.
[21] Pew Charitable Trusts, 2010.

[22] This scenario assumes an international agreement is reached sufficient to limit global average temperature rise to no more than 2° Celsius over the next century – which requires stabilizing atmospheric concentrations of CO_2e at approximately 450 parts per million (ppm). Under this scenario, the IEA projects large increases in clean energy technology investment (see IEA 2009). This case represents a very strong outcome for global action on climate change, and thus the IEA totals referenced here should not be read as market forecasts; rather, they are used to illustrate the potential scope of these markets if all major emitters take strong action to reduce their carbon emissions.
[23] Clean power generation technologies include renewables (wind, solar, biomass, geothermal, and hydropower), CCS, and nuclear power. The U.S. figure includes $228 billion for renewables, $35 billion in CCS technology, and $87 billion in nuclear power. The global figure includes about $1.7 for renewables, $58 billion for CCS, and $422 billion for nuclear power. Investment totals in the period 2021-2030 are substantially larger under this scenario, as new technologies gain commercial viability – for example, cumulative global investment in CCS reaches $537 billion between 2021 and 2030.
[24] According to the IEA, vehicle efficiencies do improve under a business-as-usual scenario thanks to increased fuel economy standards in many countries; however, plug-in hybrids and electric cars still account for just 0.3 percent of the global passenger car fleet in 2030.
[25] UNEP and Clean Energy Finance 2009.
[26] "Global Futures 2009: Clean Energy Investment Not On Track to Prevent Climate Change," Presentation by Michael Liebreich, Chairman and CEO, New Energy Finance. Barcelona, April 21st, 2009.
[27] Creyts, J. et al. "Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?" McKinsey and Company, December 2007. Investment totals are in 2005 dollars. This assumes action sufficient to limit U.S. GHG emissions about 7 percent below 2005 levels by 2030 (a fairly modest target relative to what most legislative proposals have called for)
[28] Granade, H.C. et al. 2009. The study estimates that the pursuing all efficiency measures would be enough to abate 1.1 gigatons (GT) of CO_2e a year below business-as-usual by 2020.
[29] IEA 2009.
[30] Bloomberg New Energy Finance. "Clean energy investment down just 6.5% in 2009; Asia outstrips the Americas," Press release, January 7th, 2010 and Pew Charitable Trust 2010.
[31] Interview with Dan Arvizu, Director, National Renewable Energy Laboratory. Environment and Energy Daily T.V.: OnPoint. Aired January 12, 2010.
[32] "Wind Turbine Market Share Revealed," Environmental Leader: Energy and Environmental News for Business, March 5, 2009.
[33] Testimony of Dan Reicher, Director, Climate and Energy Initiatives, Google. United States Senate Committee on Environment and Public Works full committee hearing. "Legislative Hearing on S.1733, Clean Energy Jobs and American Power Act," Wednesday, October 28th, 2009.
[34] A comparative advantage exists when a country (or a firm) can produce something at a lower relative cost compared to any other. This includes the cost of what is given up in order to produce a particular good – the opportunity cost. Note that even if a country is the best at making something, it doesn't necessarily have a comparative advantage in its production. If country A is much better at producing cars than country B, but is only slightly better than country B at producing bicycles, it makes more sense for country A to devote its resources to making cars and for country B to make bicycles and for the two countries to trade.
[35] Economies of scale exist in industries where the average cost per unit of a good falls as a result of increased production. This may occur for a number of reasons, such as the development of more efficient production techniques that can only be fully realized at certain levels of output, the ability to buy inputs in bulk, regional investment in related industries or infrastructure (e.g. transportation) that helps lower costs, and many other factors. Industry clusters can have positive benefits by increasing the productivity of the firms in a cluster and spurring innovation; for example, as more firms agglomerate in a certain region, they may attract increasingly skilled and specialized workers, or exchange information that makes production more efficient. For more on the potential benefits of business clustering, see Porter, Michael. "Clusters and the New Economics of Competition," Harvard Business Review, Vol. 76, Issue 6, November-December 1998.

[36] Additional examples are noted in Burtis, P.R., B. Epstein, and N. Parker. "Creating Cleantech Clusters: 2006 Update. How Innovation and Investment Can Promote Job Growth and a Healthy Environment," National Resources Defense Council and Cleantech Venture Network LLC, 2006.
[37] For some detailed examples and discussion of environmental lead markets, see Beise, Marian and Klaus Rennings. "Lead Markets of Environmental Innovations: A Framework for Innovation and Environmental Economics," Discussion Paper prepared for the Centre for European Economic Research, 2003. See also Jänicke, Martin and Klaus Jacob. "Lead Markets for Environmental Innovations: A New Role for the Nation State," Global Environmental Politics, 4:1, Massachusetts Institute of Technology 2004.
[38] "China announces targets on carbon emission cuts," Ed. An Lu. GOV.cn, the Chinese Government's Official Web Portal, November 26th, 2009.
[39] Bonvillian, William B. and Charles Weiss. "Structuring an Energy Technology Revolution," MIT Press, Massachusetts 2009.
[40] Bonvillian, William B. "Looking at Technological Innovation in Energy." Presentation to members of the Information Technology and Innovation Foundation, July 20th, 2009.
[41] Oster, Shai. "World's Top Polluter Emerges as Green-Technology Leader," Wall Street Journal, December 15th, 2009.
[42] Bradsher, Keith. "China Leading Global Race to Make Clean Energy," The New York Times, January 30th, 2010.
[43] Bradsher, Keith. "China Drawing High-Tech Research From U.S," The New York Times, March 17th 2010, and Bonvillian July 2009.
[44] Bonvillian July 2009.
[45] China has recently announced it is eliminating its previous policy of requiring that 70 percent of all wind turbine components are produced domestically. See "China scraps limits on foreign wind turbine parts," AFP, January 12th, 2009.
[46] UNEP and Clean Energy Finance 2009.
[47] Bradsher January 2010.
[48] Crachilov et al. "The China Greentech Report 2009," Snap Printing, Shanghai, China, 2009.
[49] Bradsher January 2010.
[50] European Commission, 2008. "Climate Action and Renewable Energy Package."
[51] The scope of the ETS will expand at the commencement of its third phase in 2013.
[52] 2008 Figure: United Nations Environment Program (UNEP) and New Energy Finance, 2009. 2009 figure from Pew Charitable Trusts, 2010.
[53] Engel, Ditlev et al. "Green Jobs and the Clean Energy Economy," Thought Leadership Series, Copenhagen Climate Council, May 2009. Under a feed-in tariff policy, utilities are required to buy grid-connected renewable electricity at a pre-determined above-market rate.
[54] Engel et al 2009.
[55] Ibid.
[56] German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety. "Report on implementation of the key elements of an integrated energy and climate programme adopted in the closed meeting of the Cabinet on 23/24 August 2007 in Meseberg," 2007. For additional information, see the website of the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety.
[57] "Renewable Energy Sources in Figures: National and International Development." German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, June 2009.
[58] U.S. Department of Energy, 2009. Solar Decathlon Final Results.
[59] German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, June 2009.
[60] Ibid.
[61] German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, June 2006.
[62] Ibid. Estimates are in year 2000 dollars.
[63] Pernick, Ron and Clint Wilder. "Five Emerging U.S. Public Finance Models: Powering Clean-Tech Economic Growth and Job Creation," Clean Edge, Inc., October 2009.
[64] Meeyoung, Cho. "South Korea to spend $85 billion on green industries," Reuters, July 2009.

[65] Korean Ministry of Knowledge Economy. "Korea making 'unprecedented move' to reduce emissions," Korean Ministry of Knowledge Economy, December 2009.
[66] Holding these shares for nuclear and CCS generation constant, the researchers looked at how various targets for renewables and energy efficiency gains affected overall job-year creation. For example, assuming BAU improvements in energy efficiency and a 10 percent generation target for renewables in addition to the nuclear and CCS targets, the researchers estimate the creation of about 500,000 net job-years between 2009 and 2030. Under another case, increasing renewables' share to 40 percent of generation and improving overall energy efficiency by 0.6 percent per year while maintaining the nuclear and CCS targets would create about 7,000,000 net job-years.
[67] See, for example, Greaker, Mads. "Spillovers in the development of new pollution abatement technology: A new look at the Porter-hypothesis," Journal of Environmental Economics and Management, Vol. 52, 2006; Porter, Michael. "America's Green Strategy," *Scientific American*, 264, 4: 96, 1991; Porter, M. and C. van der Linde, "Toward a New Conception of the Environment-Competitiveness Relationship," *Journal of Economic Perspectives* 9, 4:97–118, 1995. As discussed in endnote three, this concept remains controversial and has its critics; see Ziesemer, Thomas. "The Porter Hypothesis Revisited: An Overview on Empirical and Theoretical Evidence," Papers in Global Business Management, Universität Augsburg**,** December 2007, and Palmer, Oates, and Portney, "Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm?" J. of Economic Perspectives, 9(4), 1995.
[68] The Pew Center has compiled a review summarizing several studies on the links between environmental policy and job creation, available here.
[69] Wei, Max and Shana Patadia and Daniel Kammen. "Putting Renewables and Energy Efficiency to Work: How Many Jobs Can the Clean Energy Industry Generate in the US?" University of California, Berkeley, 2009. Other studies have reached similar conclusions; see, e.g. Burtis, P.R., B. Epstein, and N. Parker, 2006.
[70] For an overview of how carbon capture and storage technology works, and its potential, see the Pew Center's carbon capture and storage factsheet, available here.
[71] "National Commission on Energy Policy's Task Force On America's Future Energy Jobs." National Commission on Energy Policy, October 2009, pp 32 and 79.
[72] These estimates are based on the 2007 National Energy Technology Laboratory (NETL) cost estimates for a new integrated gasification combined cycle power plant with and without CCS and where the number of jobs is assumed to be proportional to the estimated direct labor costs (adjusted to equate the net power output of the plant with and without CCS). See National Energy Technology Laboratory. "Energy Analyses: Fossil Energy Cost and Performance Baseline Studies, Volume 1: Bituminous Coal and Natural Gas to Electricity," NETL, August 2007.
[73] Gold, Rachel et al. "Energy Efficiency Provisions in the *American Clean Energy and Security Act of 2009*: Impacts of Current Provisions and Opportunities to Enhance the Legislation," American Council for an Energy-Efficient Economy, 2009. These provisions include the bill's combined energy efficiency and renewable energy standard, and other provisions associated with building codes, retrofits, and appliance standards.
[74] Kenley, C.R. et al., "Job Creation Due to Nuclear Power Resurgence in the United States," *Energy Policy* 37 (11): 4894-4900, 2009.
[75] This includes 38,000 manufacturing jobs by U.S. nuclear suppliers (assuming the new plants were sourced entirely from U.S. firms); 79,000 construction and operation jobs; 250,000 in indirect nuclear jobs; and the inducement of 242,000 non-nuclear jobs. Examples of direct jobs include those involved with the manufacturing or construction of the nuclear plant and equipment. Indirect jobs include those created by purchases made by directly affected industries from other industries, such as nuclear fuel supply, maintenance and repair, and engineering service. An induced job is created as a result of purchases made by those employed in direct and indirect jobs, such as restaurant and retail workers and home builders.
[76] Urbanchuck, J.M. and J. Kapell. "Ethanol and the Local Community," 2002.
[77] The wind turbine industry provides a good example of a low-carbon technology with a complex and increasingly globally integrated value chain. See Kirkegaard, Jacob and Thilo Hanemann and Lutz Weischer. "It Should Be a Breeze: Harnessing the Potential of Open Trade and Investment Flows in the Wind Energy Industry," Peterson Institute of International Economics, December 2009.

[78] Concerns are sometimes raised over the impact of climate policy on manufacturing jobs in particular. However, not only do many clean energy technologies rely on manufacturing jobs, but employment in manufacturing faces significant structural challenges unrelated to climate and energy policy, such as increased reliance on automated production. In fact, some "business-as-usual" projections anticipate declining overall employment in manufacturing even as aggregate manufacturing output increases. See United States Energy Information Administration (EIA). "Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009," U.S. Department of Energy, August 2009.

[79] Kirkegaard et al 2009.

[80] Yiyu, Liu. "Goldwind to spread wings overseas for growth," China Daily, December 15, 2009.

[81] Rahim, Saqib. "Plant for Nissan's Leaf gets a $1.4 billion DOE loan," Climatewire, January 29th, 2010.

[82] Pasternack, Alex. "China's Suntech Will Build Solar Panels in the U.S.," Treehugger.com, May 15th, 2009. See also Burnham, Michael. "China's solar king plots U.S. manufacturing plant," Environment and Energy Daily, May 11th, 2009.

[83] Woody, Todd. "U.S. Solar Firm Cracks Chinese Market," The New York Times, September 8th, 2009.

[84] Martin, Christopher and Jim Efstathiou Jr. "China's Labor Edge Overpowers Obama's 'Green' Jobs Initiatives," Bloomberg News Service, February 2nd, 2010.

[85] Kirkland, Joel. "ESolar licenses solar technology to Chinese utilities." ClimateWire, January 12th, 2010.

[86] LaMonica, Martin. "GE inks deal for 'cleaner coal' in China," Green Tech (online), part of CNET News, November 17th, 2009.

[87] Bonvillian July 2009; see also Bonvillian and Weiss 2009.

[88] Mandel, Jenny. "Chu's 'innovation hub' plan gets rolling," Environment and Energy Daily, December 23rd, 2009.

[89] For more information, visit the ARPA-E website at United States Department of Energy, Advanced Research Projects Agency – Energy.

[90] For more information on CEDA and the other provisions in the ACES Act, see the Pew Center's detailed summary of the bill here.

[91] For more information on how the ARRA funds are being distributed, see the Pew Center's white paper on the U.S. Department of Energy's recovery act spending.

[92] U.S. DOE. "Recovery Act Announcement: President Obama Awards $2.3 Billion for New Clean-Tech Manufacturing Jobs," January 8th, 2010.

[93] White House Office of the Press Secretary. "President Obama, Vice President Biden to Announce $8 billion for High-Speed Rail Projects Across the Country," January 28th, 2010.

[94] White House Office of the Press Secretary. "Economic Impact of the American Recovery and Reinvestment Act of 2009, Second Quarterly Report," January 13th, 2009. This includes direct, indirect, and induced jobs (see endnote 75 for a definition of an induced job).