policy brief

NI PB 11-05 | July 2011 | nicholasinstitute.duke.edu

The United States, China, and the Competition for Clean Energy

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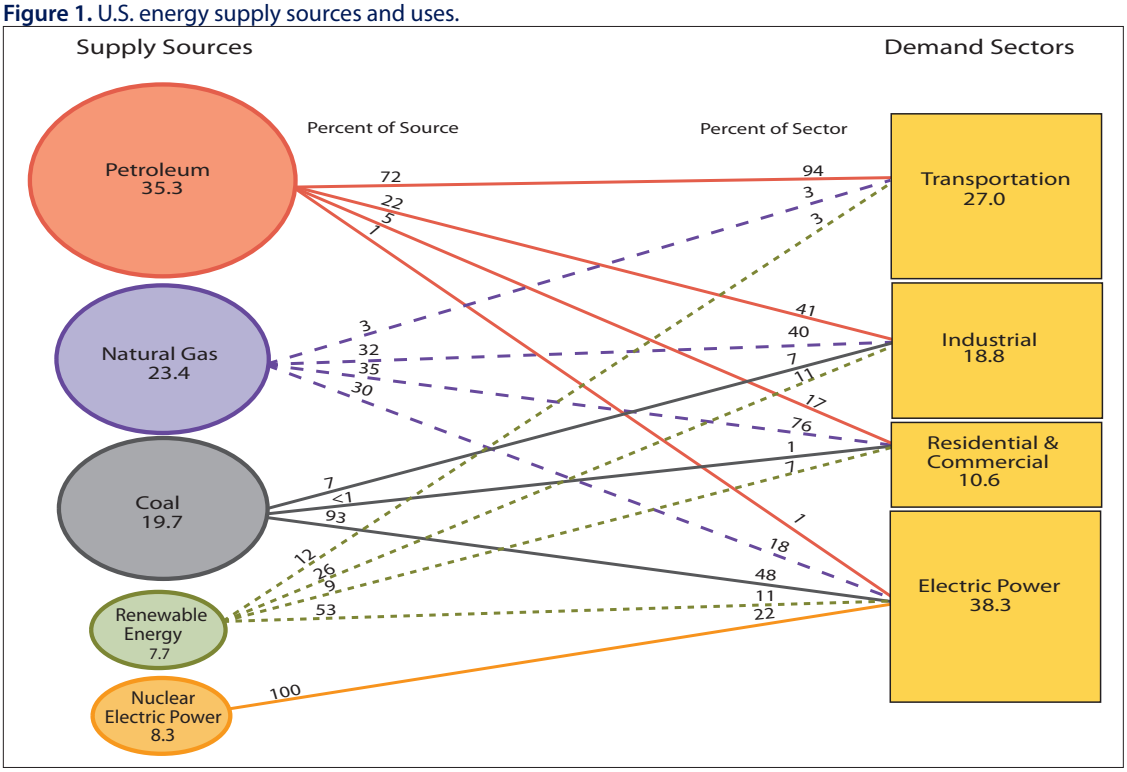
The Push and Pull for Clean Energy

The United States is now grappling with the challenge of meeting its long-term energy needs in a secure, affordable, reliable, safe, and environmentally sustainable way. Achieving this goal and meeting these objectives simultaneously presents numerous challenges and opportunities. Fossil fuels have been the primary source of energy for the U.S. and other developed countries for centuries because they have been relatively abundant, accessible, and inexpensive when using traditional measures of cost. Tapping fossil fuels was one of the driving factors behind the 19th-century industrial revolution and can be credited for its role in creating economic prosperity and helping to lift millions of people out of extreme poverty.[2] Currently, the U.S. relies on fossil fuels (petroleum, coal, and natural gas) to meet about 84% of its energy needs, on nuclear energy for 9%, and on hydropower and other renewables for the remaining 7% (See Figure 1).

Figure 1. U.S. energy supply sources and uses.



Source: U.S. Energy Information Administration, Annual Energy Review 2009, Tables 1.3, 2.1b-2.1f , 10.3, and 10.4. Found at http://www.eia.doe.gov/aer/pecss_

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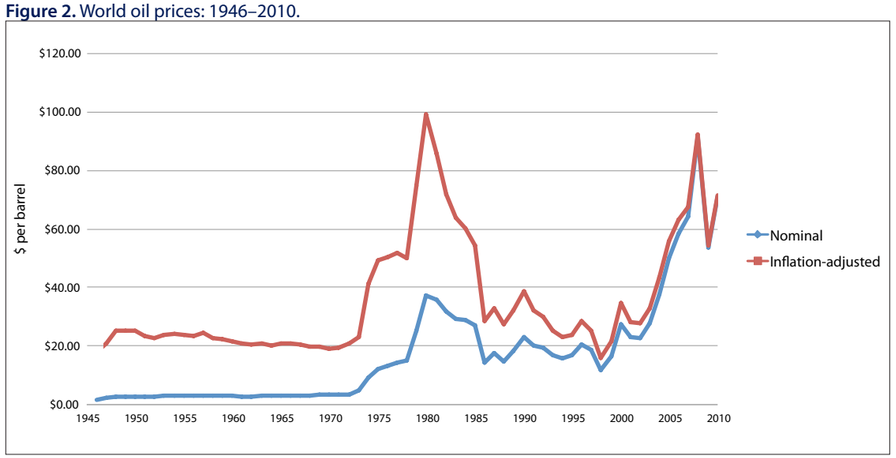
2. Jeffrey Sachs, *The End of Poverty*. 2005. The Penguin Group.

diagram.html.

However, there is growing concern about the full cost of fossil fuel exploration, extraction, and combustion. Much of the cost concern has revolved around petroleum, as we have seen wide swings in prices, especially over the middle of the last decade as demand was expanding faster than supply, leading to a surge in prices (see Figure 2) and concerns over "peak oil."[3] This was followed by a major contraction in the world economy (2008–2010) that saw oil prices plummet as demand dropped sharply. More recently (2011) oil prices have shot back up as the global economy slowly recovers and supply concerns are being upset by the political unrest in the Middle East.

Figure 2. World oil prices: 1946–2010.



Source: InflationData.com © Copyright 2010 and Timothy McMahon.

These ongoing concerns about petroleum supply and demand shocks and the immediate effect felt at the gas pump and industrial operations have driven calls for greater energy security and more reliable and diverse sources that are not as susceptible to market shocks. This has produced calls from various parties for solutions ranging from more exploration to alternative fuel sources to greater fuel efficiency to reduced demand through better transportation planning.

The option of alternative fuel sources leads us to the other, mostly hidden cost associated with fossil fuel combustion: emission of greenhouse gases (GHGs) and other air pollutants. This problem extends well beyond petroleum and the transportation sector into electric power generation and other industrial processes that use fossil fuels. Emissions of conventional air pollutants such as nitrogen oxides (NO_x), ozone, mercury, and sulfur dioxide (SO_2) have been regulated from many mobile and stationary sources in the U.S., but GHGs contributing to climate change have gone largely unregulated, except at the state level.[4] This is now changing, as the U.S. EPA implements new regulations governing GHG emissions pursuant to the Clean Air Act.[5] Attempts at comprehensive federal legislation to regulate GHGs through a comprehensive cap-and-trade program across all major emitting sectors passed the U.S. House of Representatives in summer 2009,[6] but was stalled in the Senate the following year.

As the U.S. has struggled to find its footing on domestic GHG policy, it remains party to international negotiations

3. Peak oil is a concept popularized in the mid-2000s widely attributed to the late petroleum expert Matthew Simmons, but it has roots in the 1950s in the work of Marion King Hubbert.
4. Regional Greenhouse Gas Initiative (RGGI) caps GHGs from the electric power sector in 10 northeastern states. California's AB 32 legislation caps GHGs for that state and is slated to commence in 2012.
5. To date, the EPA has issued a Greenhouse Gas Reporting Rule (74 FR 5620), rules governing GHG emissions from passenger vehicles and light-duty trucks (75 FR 25323), and permitting requirements for certain large sources of GHG emissions (including new facilities or existing facilities undergoing major modifications) (75 FR 31514). The Agency is in the process of creating new source performance standards governing GHG emissions from fossil fuel–fired power plants and refineries (http://www.epa.gov/airquality/ghgsettlement.html).
6. *HR 2454 – American Clean Energy and Security Act*, introduced by Congressman Henry Waxman (D-CA) and Edward Markey (D-MA), passed in the U.S. House of Representatives by a vote of 219–212.

under the United Nations Framework Convention on Climate Change (UNFCCC). In those negotiations, most recently codified in Cancún, Mexico, in December 2010, the U.S. and other countries committed to reduce GHGs by 2020 and fund mitigation and adaptation activities in developing countries. China, now the world's largest emitter, has agreed to cut its GHG emissions intensity (GHGs per unit of GDP) by 16% to 17% by 2015, and by 40% to 45% by 2020. As discussed below, China's goals are reflective of their recent commitment to scientifically balanced development and the development and deployment of renewable and other clean energy sources. Since mid-decade, China has gone from being a relatively small player in clean energy to the world's largest investor.[7]

Despite the failure to pass domestic climate legislation, clean and secure energy remains a domestic policy goal with fairly broad political support, as advanced by President Obama in his January 2011 State of the Union Address, in a significant speech on energy policy in March 2011, and in legislative proposals from both political parties, as discussed below. While some of the focus on "clean energy" may be to avoid overt reference to GHGs and climate change as a policy driver, the fact remains that moving from an energy system highly reliant on fossil fuels, GHGs, and—in the case of petroleum at least—on supplies from politically unstable regions has relatively broad appeal for various national security as well as environmental constituents. Moreover, with the U.S. and much of the rest of the world only slowly recovering from a massive economic downturn, some see retooling toward a more clean energy system as a potential source of technological innovation and economic development. In President Obama's words, it is an attempt to "win the future."[8]

With this as background, we pose the following questions, all aimed at identifying how best should the U.S. advance its interests with respect to clean energy:

- What is the current state of affairs in the U.S. with regard to the development and deployment of clean energy, both in absolute terms and relative to China and other major economies?
- What does it mean to lead or follow in clean energy?
- Is China's decision to expand its use and development of clean energy technologies, on net, good or bad for the U.S.?
- What are the policy options for the U.S. moving forward?
- What do we know and what do we need to know to answer these questions?

Recent U.S. Clean Energy Policy Initiatives

Absent the passage of comprehensive climate legislation in the Congress, which would have placed significant constraints on fossil energy and strong incentives for low- or zero-carbon energy, policies to enhance clean energy have focused on economic stimulus expenditures and new proposals from the White House and Congress on future clean energy targets. The American Recovery and Reinvestment Act of 2009 (ARRA) in particular marked a significant increase in the level of government support for the development and deployment of clean energy technologies, including:

- $3.4 billion for carbon, capture, and storage technologies;
- $2 billion for "science and innovation," including $400 million for the Advanced Research Projects Agency-Energy (ARPA-E);
- $1.64 billion for the development and deployment of renewable energy technologies;
- $12 billion to fund energy efficiency improvements; and
- $4.5 billion for modernizing the electricity grid.[9]

The ARRA also expanded the U.S. Department of Energy's loan guarantee program—originally focused on the nuclear power industry—to include renewable energy, electricity transmission, and biofuels projects.[10]

During the summer and early fall of 2010, as the debate over climate legislation stalled in the U.S. Senate, Senators

7. *Bloomberg New Energy Finance, January 11, 2011.* http://www.bloomberg.com/news/2011-01-11/low-carbon-energy-investment-hit-a-record-243-billion-in-2010-bnef-says.html.
8. State of the Union Address, January 25, 2011
9. http://www.energy.gov/recovery/.
10. 42 U.S.C § 16511, 16516.

Richard Lugar (R-IN) and Lindsey Graham (R-SC) released bills calling for a Clean Energy Standard (CES).[11] The proposals build on the model of renewable portfolio standards (RPS) and renewable electricity standards (RES) already in place in more than half of the states, establishing an annual target for clean energy production and allowing covered entities to trade credits to meet their compliance obligations. These senators' CES proposals expanded the definition of clean energy beyond renewable energy technologies to include nuclear energy generation and carbon, capture, and storage (CCS) technologies.

In his 2011 State of the Union Address, President Obama called for an increase in government support for technology innovation and announced the goal of generating 80% of the nation's electricity from clean energy technologies by 2035.[12] To achieve the goal, the White House issued a CES proposal similar to those proposed by Senators Lugar and Graham.[13] In addition to allowing credits for nuclear energy and CCS technologies, the White House CES would also allow partial credit for "clean coal and efficient natural gas" generation.[14]

The Senate Committee on Energy and Natural Resources is currently examining the CES concept. Senators Jeff Bingaman (D-NM) and Lisa Murkowski (R-AK), chairman and ranking member of the committee, respectively, issued a CES white paper on March 21, 2011, outlining the current state of clean energy development in the U.S. and seeking stakeholder feedback on a series of pointed questions regarding how the CES will meet specific goals and how those will be accomplished.[15] The list of questions includes: (1) the threshold for inclusion in the program (i.e., what generation levels should qualify), (2) what resources should qualify as "clean energy," (3) how the credit system should be designed, (4) how CES will affect deployment of specific technologies, (5) cost issues and appropriation of payments for noncompliance, and (6) what other policies will be needed to meet CES proposal of 80% clean energy by 2035.[16] Senators Bingaman and Murkowski continue to pursue this issue, including the potential development of a Clean Energy Deployment Administration to jump-start the commercialization of clean energy technologies.

On March 30, 2011, the White House released a broad "Blueprint for a Secure Energy Future."[17] The Blueprint seeks to achieve the multiple goals of increasing energy security, reducing consumer costs through energy efficiency, and strengthening the U.S. economy by "creating markets for innovative clean technologies that are ready to deploy, and by funding cutting-edge research to produce the next generation of technologies."[18] Specific goals outlined in the Blueprint include:

- expanding "safe and responsible" domestic oil and gas production;
- reducing oil demand and increasing supplies of oil;
- increasing vehicle efficiency and diversifying the transportation fuel mix;
- improving energy efficiency in homes and commercial buildings;
- expanding U.S. innovation in clean energy technologies, including a continued commitment to research and development efforts; and
- improving efficiency in the federal government's buildings and vehicle fleet.[19]

11. The Clean Energy Standard Act of 2010, S. 3183, 111th Cong.; The Practical Energy and Climate Plan Act of 2010, S. 3463, 111th Cong.
12. http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address. By the White House's calculation, the qualifying clean energy technologies currently provide 40% of the nation's electricity. The White House, President Obama's Plan to Win the Future by Producing More Electricity Through Clean Energy.
13. The White House, Blueprint for a Secure Energy Future, March 30, 2011, at 35–36.
14. The White House, President Obama's Plan to Win the Future by Producing More Electricity Through Clean Energy.
15. Sens. Jeff Bingaman and Lisa Murkowski, White Paper on a Clean Energy Standard, March 21, 2011, http://energy.senate.gov/public/_files/CESWhitePaper.pdf.
16. *Id.*, at 2–6.
17. The White House, Blueprint for a Secure Energy Future, March 30, 2011. http://www.whitehouse.gov/sites/default/files/blueprint_secure_energy_future.pdf.
18. *Id.* at 4.
19. The White House, Blueprint for a Secure Energy Future, Mar. 30, 2011, at 5–8.

A Surge in China's Clean Energy Efforts

In 2010, China climbed to the top of the list of countries attracting investment in clean energy technologies, with $54.4 billion of new investment, followed by Germany at $41.2 billion and the United States at $34 billion.[20] This reflects a remarkable change in global investment dynamics. As recently as three years ago, China was a relatively small investor in clean energy. Strong central policy directives appear to have provided the impetus for this surge in investment.

Since China's current president, Hu Jintao, formally came into power in 2003, the Chinese government has moved away from its previous development path by expanding the concept of economic growth. The new governing ideology, "the scientific view of development," emphasizes development with a greater emphasis on energy and environmental protection.[21] In early 2011, Premier Wen Jiabao stated that China's current economic policy, based on low-cost manufacturing, is "unbalanced, unstable, uncoordinated, and unsustainable." China, Wen argues, should focus on developing higher-value-added and innovative technology sectors, including clean energy technologies.[22]

During the global financial crisis in 2008–2009, the Chinese government initiated a RMB¥ 4 trillion (US$586 billion) stimulus package. A significant portion (estimated US$221 billion) was to be spent on renewable energy and other clean technologies. China is already the world's biggest producer of solar panels and wind turbines, and it continues to invest aggressively in clean energy.

China's political and industrial structures differ greatly from those in the United States. The Chinese government has direct ownership in most of the country's energy sectors, including the three major oil companies, five major power generation groups, two electricity grid companies, and two nuclear power companies. Furthermore, the Chinese banking system is largely state-owned and closely follows political directives. As such, national plans—the cornerstone of central economic policy in China for more than half a century—remain a key policy instrument for the Chinese economy, especially in the energy sector. The widespread government ownership and control over China's energy sector allows the Chinese government to exercise industrial policies and target sectors for advancement. Technology indigenization and fostering national industries are well-embraced policy goals.

In the 11th five-year plan (2006–2010), China set ambitious targets of a 20% reduction in energy intensity (energy per unit of GDP) and a 10% reduction in major pollutants. For the first time, China set quantitative and legally binding targets on energy intensity in its five-year plan. The 20% energy-intensity target was equivalent to annual reduction of 1.5 billion tons of CO_2 emissions.[23] In contrast to previous five-year plans, Chinese national leaders emphasized the energy and environmental targets in the 11th five-year plan and largely managed to achieve those targets.[24] This achievement signals an important policy change in China's long-term development strategy.

China's 12th five-year plan (2011–2015) highlights the coming opportunities and challenges in the country's energy sector. Key energy-related targets in the 12th five-year plan include:[25]

- Reduce energy intensity by 16%
- Generate 11% of energy from nonfossil fuels (including conventional hydropower, nuclear power, wind, solar, and biomass) by 2015
- Promote (with preferential tax, fiscal, and procurement policies) seven "Strategic Emerging Industries" (SEIs), three of which are directly energy-related:
  - biotechnology

20. Friedman, Lisa. "China continues to lead U.S. in clean energy investment," *Climate Wire*, March 29, 2011, using data from *Bloomberg New Energy Finance*.
21. Xu, Y., Williams, R. H., and Socolow, R. H., 2009. China's rapid deployment of SO_2 scrubbers. *Energy & Environmental Science* 2 (5): 459–465.
22. Bremmer, Ian, and Evan A. Feigenbaum. "Watch Out for Rising U.S.-China Competition" *Harvard Business Review blog (The Conversation)*. Friday April 1, 2011. http://blogs.hbr.org/cs/2011/04/watch_out_for_rising_us-china.html.
23. Lin J., Zhou N., Levine M., and Fridley D. Taking out 1 billion tons of CO_2: The magic of China's 11th Five-Year Plan? *Energy Policy* 2008; 36(3):954–70.
24. During the 11th five-year plan, China reduced energy intensity by 19.1%, which was very close to the original 20% target. SO_2 emissions were reduced by 14% and chemical oxygen demand (COD), an indicator for water pollution, by 12%; both exceeded the original 10% target. http://news.xinhuanet.com/politics/2010-12/21/c_12903831.htm (In Chinese) and http://dt.people.com.cn/GB/14251625.html (In Chinese).
25. Copsey, T. and Hilton, I., 2011. Greening China: Outlook for European SMEs, chinadialogue.

  - new energy
  - high-end equipment manufacturing
  - energy conservation and environmental protection
  - clean-energy vehicles
  - new materials
  - next-generation information technologies
- Extending sector consolidation in automotive, steel, cement, machinery, aluminum, and rare earth materials

In addition to the five-year plans, the Chinese government has also set a goal of obtaining 15% of the country's total energy from nonfossil sources by 2020. According to the *Renewable Energy Mid-to-Long-Term Plan*, China plans to reach 300 gigawatts (GW) of installed hydropower (225 GW conventional, 75 GW small hydro) capacity, 30 GW of biomass electricity, 30 GW of wind power, and 1.8 GW of photovoltaic electricity by 2020.[26] The *Nuclear Power Mid-to-Long-Term Plan* set the target of 40 GW of installed nuclear power capacity by 2020.[27] Since these mid- to long-term plans were announced in 2007, several targets have been revised upwards. The 2020 targets of wind and photovoltaic power were later revised upward to 100 GW and 20 GW, respectively.[28] The 2020 nuclear power target was later revised upward to 80–100 GW.[29] After the Fukushima nuclear disaster in Japan, the nuclear target may be revised downward, while the photovoltaic target may be revised upward.[30]

The unique Chinese political and industrial structures make it very difficult, if not impossible, for other countries to emulate Chinese strategies of development. Chinese clean energy industries are rising quickly as competitors in the global market. Significant entry barriers for foreign investors exist today and likely will continue. Whether international negotiations (for example, the Word Trade Organization) can effectively bring down those barriers remains to be seen. Nevertheless, because of the sheer size of the Chinese economy and its rapid growth, even a small market share represents a large business opportunity. Whether U.S. industries can seize these opportunities and overcome these barriers may depend on better coordination between the U.S. government and industry. Moreover, as discussed below, the expansion of the Chinese supply of clean energy technologies could provide benefits to users of those technologies in the United States.

What Is at Stake? Defining the Rewards

The call for clean energy in the U.S. and the continued rapid growth in China's clean energy presents both tremendous challenges and opportunities for U.S. competitors and investors. If the clean energy goals of the U.S., China, and the rest of the world are to be met, the size of the economic pie at issue is enormous. Global annual consumption of electric power is approximately 18 trillion kilowatt hours (kWh), valued roughly at $2 trillion,[31] or about 5% of global GDP. The U.S. and China account for about 22% and 17% of total electricity consumption, respectively—each far and above larger than any other single country. The gap in per capita energy consumption between the two countries is high (see Figure 1), leaving room for even further growth in China as economic growth continues. While U.S. power demand is expected to grow about 1% per year until 2020, China's power demand is expected to grow 5% through 2020, down from 9% per year during the last five years.[32] Thus the growing clean energy shares in the electric power sector in these countries alone could generate multiple hundreds of billions of dollars of value for clean energy producers.

This presents a huge opportunity for those who can supply the clean energy side of the market, from developing the technologies to making the equipment to installing the infrastructure to generating and distributing the product. It is important to recognize that clean energy expansion occurs in part by displacing other energy sources. To some extent, clean energy producers win, and "dirty" energy producers either shift to clean or risk losing the market. This is competition at its essence, and competition is likely to spur innovation and deployment of clean energy technologies both as an offensive and defensive strategy. Thus, if the domestic policy goal is to make U.S. producers and technologies more competitive in the domestic and global power sector, the focus should be on conditions that enable that to occur.

26. NDRC, 2007. Renewable Energy Mid-to-Long-term Plan (In Chinese). Beijing, National Development and Reform Commission.
27. NDRC, 2007. Nuclear Power Mid-to-Long-term Plan (In Chinese). Beijing, National Development and Reform Commission.
28. http://cn.reuters.com/article/CNEnvNews/idCNCHINA-4060620110330 (In Chinese).
29. http://www.snptc.com.cn/templates/list1/index.aspx?nodeid=36&page=ContentPage&contentid=20468 (in Chinese).
30. http://cn.reuters.com/article/CNEnvNews/idCNCHINA-4060620110330 (In Chinese).
31. Data from International Energy Agency and U.S. Energy Information Administration's respective annual energy outlook and statistics.
32. "Joined at the hip: The U.S.-China clean energy relationship." *Bloomberg New Energy Finance*. May 17 2010.

Table 1. Total energy consumption per capita: U.S. and China (tons of oil equivalents).

	U.S.	China
2000	7.92	0.87
2001	7.69	0.86
2002	7.71	0.93
2003	7.66	1.05
2004	7.75	1.21
2005	7.71	1.30
2006	7.57	1.42
2007	7.62	1.49
2008	7.38	1.60
2009 (e)	6.95	1.69

Source: International Energy Agency.

China's Clean Energy Play: A War, a Game, or a Growth Opportunity for the U.S.?

Given the stakes, it is perhaps unsurprising that the rhetoric surrounding the clean energy policy debate often suggests winners and losers in absolute terms. It is not uncommon for the terminology to frame the push for clean technology development as a war, with the implication that one country will win and others will lose.

"Investor Report: China Now Winning the Green Energy War"[33]

"The cold war in clean energy"[34]

"For many U.S. firms, the first battleground will be within China, where there is already significant competition between foreign and local companies for market share."[35]

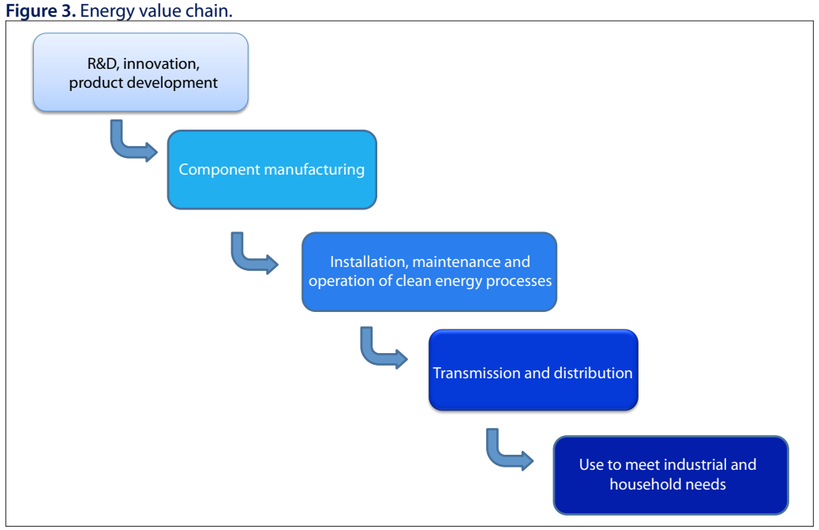
While there is some motivational power in describing matters in terms of a clean energy war—it makes clear the goal of producing more clean energy than the competition—it can also be misleading. In contrast to war, where there is both a conquering party and a conquered party, economic battles to produce and distribute better technologies can make winners not only of those who are the first or best at *supplying* the product, but also of those who ultimately get to *use* the better product. One country can win the battle if its companies gain market advantage by being the earliest or best producer. But another country's consumers can also win by having access to cleaner, more efficient energy than they would otherwise have, even if the technologies that produce that energy are sourced in another country. At their essence, these are the principles of comparative advantage and gains of trade.

Thus the issue is similar to many other economic issues, from both a supply and a demand perspective. As a matter of policy, the question is whether it is in the United States' best interests to pursue a strong position in supply, or to seek a better situation for its clean energy demanders. Or can it do both?

The value chain for clean energy is complex; it is not a simple issue of "Made in America" or "Made in China." There are several links in the chain (Figure 3).

33. http://www.fastcompany.com/1687690/china-overtakes-us-in-ernst-young-renewable-energy-rankings.
34. *Christian Science Monitor, October 19, 2010* (http://www.csmonitor.com/Commentary/the-monitors-view/2010/1019/The-cold-war-in-clean-energy).
35. Bremmer, Ian and Evan A. Feigenbaum. "Watch Out for Rising U.S.-China Competition" *Harvard Business Review blog (The Conversation)*. Friday April 1, 201. http://blogs.hbr.org/cs/2011/04/watch_out_for_rising_us-china.html.

Figure 3. Energy value chain.



Each of these links has forms of specialization that may distribute the value across countries. For example, a wind turbine now operating in the state of Pennsylvania is a complex combination of basic scientific knowledge of aerodynamics developed by a German scientist, Albert Metz, in 1919, embodied in a foundation, tower, and blades, which together consist of thousands of components produced and assembled all over the world. The turbine is installed onsite primarily by U.S. labor, and the electricity it generates is distributed through a domestically produced electric power grid to Pennsylvania factories, commercial buildings, and households.

The U.S. has played a key role in the R&D and innovation stage of clean energy technologies. For instance, the first solar cell was developed by Bell Laboratories in the 1950s,[36] and the solar power industry developed throughout the U.S. in the 1970s and 1980s. The U.S. is still a leading recipient of venture capital for new product development in this area, but its dominance is slipping as other countries have ramped up their focus on basic and applied research and development. China is increasing its emphasis in this area, as indicated earlier with the new emphasis on science in its latest five-year plan. China is now breaking ground on several new universities to feed this growing desire for scientific prominence. Some of this growth is in collaboration with universities from the U.S. and the rest of the world.[37]

There are clear benefits to those who develop and can effectively license (and enforce their intellectual property rights for) new products, with much of the value retained by entrepreneurs, scientists, and other "high-tech" workers. But there is also value added in the rest of the chain, all the way from the component factory workers and managers, to the engineers who design grid networks, to the truck and train operators who transport parts, to the construction workers who build generation units, to the designers, makers, and installers of energy efficiency systems. Beneficiaries of the same technology stream (e.g., wind, solar, biofuels) will generally reside in different countries as long as the borders are open to trade in clean energy goods and services. There are numerous examples of U.S. companies partnering with Chinese companies on clean energy initiatives. For example, in late 2010, GE announced a partnership with a Chinese company (Harbin) to manufacture GE-designed wind turbines for the Chinese market.[38] Duke Energy, soon to be the United States' largest electric utility,[39] has an ongoing partnership with the Chinese firm ENN to operate electric generation plants in China, including a joint effort to provide power in Langfang, China's first smart energy "eco-city."[40]

36. http://www.solarcompanies.com/inventor-solar-panel.
37. Indeed, our own university is establishing Duke Kunshan University, in partnership with the Chinese city of Kunshan. It is slated to open in 2012.
38. "GE Sets up Chinese Wind Turbine Joint Venture." *Renewable Energy World.com* (Sept 28, 2010). http://www.renewableenergyworld.com/rea/news/article/2010/09/ge-sets-up-chinese-wind-turbine-joint-venture.
39. Duke Energy Press Release, Duke Energy and Progress Energy to Merge, Jan. 10, 2011, http://www.duke-energy.com/news/releases/2011011001.asp.
40. "Duke's ENN Partnership." *China Solar Energy* (January 21, 2011). http://chinasolarenergy.blogspot.com/2011/01/dukes-enn-partnership.html.

Trade policy is a significant factor as well, raising questions about whether China's expansion of clean energy targets will allow for producers from other countries to benefit. U.S.-China trade relations run far deeper than the clean energy sectors, but there has been clear spillover between the two issues. In late 2010, the Obama administration filed a complaint with the World Trade Organization (WTO) over China's clean energy subsidies. The administration argued in its complaint that China is illegally subsidizing the production of wind power equipment and requiring the use of components made in China.[41] China countered that its efforts in wind energy and other renewables are manifestations of its efforts to expand energy supplies in a more sustainable manner and of its evolving commitments under international climate negotiations (UNFCCC). On June 6, 2011, the WTO ruled against China on this matter and determined that it was violating terms of the WTO agreement against subsidizing exports via local content requirements.[42]

The U.S. and China are not the only players in the market. Europe's relatively long history of renewable energy subsidies such as feed-in tariffs has established a viable regional market, both on the demand and the supply side. Brazil has become a significant player in renewables, especially in biofuels, and with the recent Fukushima nuclear disaster, Japan may consider greater investments in renewable energy if it continues to pursue its GHG emissions commitments with less reliance on nuclear energy.

Future Policy Considerations

China's recent clean energy surge has altered the landscape by significantly raising the volume of new activity, changing where it is located and sourced, and upping the ante for other countries such as the U.S. to decide whether to aggressively compete for market primacy or cede this to China. This raises the question, what would it mean for the U.S. to aggressively compete? China has gotten to this point quickly with a combination of demand-side pull and supply-side push strategies. The demand-side pull includes specific clean energy targets dictated by government mandates and financial incentives. The supply-side push includes a mix of government investment in many stages of the value chain, subsidies, and partnerships with the private sector (both Chinese and foreign companies).

As pointed out above, the Chinese economic model is distinct and not entirely replicable in the U.S. context, but there are parallel policy decisions that the U.S. could consider, including the following:

- *Demand-side incentives*
  - Mandate targets for clean energy (e.g., a federal clean energy standard or, as now exists, dozens of different state renewable energy standards)
  - Mandate energy efficiency standards to reduce the demand for all energy, whether "dirty" or "clean"
  - Give (via executive order or legislation) preferential treatment to clean energy or clean energy–sourced products in government purchases and building decisions
  - Reconsider a price on carbon, either in the cap-and-trade model considered by the previous Congress, or through a carbon fee on emissions from other sectors
- *Supply-side incentives*
  - Investment in basic science underpinning energy production and use
  - Investment tax incentives, competitive grants, or other incentives to catalyze U.S.-based component manufacturers
  - Investment (direct or through tax incentives) in clean energy infrastructure (e.g., transmission lines from renewable energy hotspots to population centers, smart grid)
  - Coordination among regulatory agencies and other government entities on multi-jurisdictional issues such as siting, pollution control, and safety

This list is not meant to be complete or exclusive. Nor is it meant to suggest that one approach (e.g., government mandates) is necessarily preferred to another (e.g., private sector positive incentives), or even that strong federal government action is necessary. Rather it is a menu for policy makers to consider as they evaluate whether to more aggressively pursue clean energy initiatives. Several of these options have been proposed, evaluated, and even implemented (see discussion above about ARRA), but it is probably fair to say that the current portfolio of policies on the books does not

41. Chan, Sewell. "U.S. Says China Fund Breaks Rules." *New York Times*, December 22, 2010.
42. http://www.newenergyworldnetwork.com/renewable-energy-news/by-technology/wind/wto-ruling-against-china%E2%80%99s-clean-energy-policies-to-rock-us-relations.html.

provide strong enough incentives to fundamentally transform the U.S. clean energy landscape—certainly not in the way envisioned by President Obama's call for 80% clean energy by 2035. Given that public policy is likely to be the impetus behind clean energy expansion for the foreseeable future, clear and sustained policy signals will be necessary to provide investment certainty to drive such an expansion.

As for whether the sudden Chinese expansion into clean energy is, by itself, good or bad for the U.S., one could argue that if the U.S. indeed wants to get to 80% clean energy by 2035, it will need all the reliable and affordable sources it can get, regardless of where the technologies are developed or where the different components are made. From that perspective, if the U.S. makes such a demand-side commitment, China's push is probably, on net, a good thing if it can expand the supply of reliable and affordable clean energy for the U.S. market.[43]

A key policy question, then, is, what is the best U.S. response to the challenge of its own ambitious demand mandate and to China's (and others') strong momentum on the supply side? Mandating U.S. demand for clean energy does not guarantee U.S. preeminence in supply. That requires creating the right environment in which U.S. suppliers can succeed. There are many spots in the supply chain, from R&D and component manufacturing to infrastructure development and generation and transmission. Do U.S. producers need strong positions in all of those markets, or should there be a strategic emphasis on the parts of the market where the U.S. has the strongest comparative advantage? And if U.S. clean energy supply is to be driven by comparative advantage, does this require a strong role by government to cultivate and advance certain areas of comparative advantage, or should this be left to a competitive market to decide?

There is a call in many quarters for the clean energy sector to be part of—and even lead—an economic renaissance for America. President Obama has repeatedly referred to this issue and time as "our Sputnik moment."[44] This has intuitive appeal, as more evidence mounts that the energy system on which the U.S. relies is in need of serious rejuvenation as the energy resource situation changes, the security and environmental implications of energy production and use are better understood, and the tools to solve the problem seem to have an attractive mix of "high-tech" and "low-tech" solutions. Numerous studies show that increasing energy investment can expand economic output and employment. This should, in many ways, be self-evident, as spending money on a certain set of activities leads to the deployment of workers and capital and creates output. From an economic policy standpoint, the issue needs to be looked at with the understanding that investment funds have many uses, and that funds invested in clean energy will not be available for other purposes. The net economic impact of cleaner energy policies must consider not only the direct impact of those expenditures on economic activity (e.g., output, employment) in the clean energy sector, but the opportunity cost of forgoing those investments in other parts of the economy. There are many reasons to believe that the total returns to clean energy investment could be quite high relative to other investment uses, especially considering the externality costs of "dirty" and volatile energy sources. But such claims could be confirmed by solid empirical analysis of investment alternatives.

More Information Needed

Assessing the opportunities for expanding the clean energy sector in the U.S. and the impacts of clean energy developments in China requires further information and analysis in a number of areas. For example, the lack of publicly available data on investment and deployment trends hampers an accurate assessment of the current state of affairs and the trajectory of the clean energy sector, as does the lack of consensus regarding what qualifies as clean energy and how to measure employment impacts.[45]

Evaluating impacts and options also depends on the goals that policy makers hope to achieve and the specific mechanisms employed to do so. The seemingly consistent policy goals of reducing GHG emissions and developing a domestic clean technology manufacturing base may lead lawmakers to quite different policy choices. A carbon price—the centerpiece of recent congressional efforts to enact comprehensive climate and energy legislation—is agnostic regarding which country produces the clean technologies or even which technologies are used. Similarly, a CES that sets targets

43. Murray, Brian. "Demand is a Start, but Supply is Needed" *National Journal Expert Blogs (Energy & Environment)*, Feb 4, 2011. http://energy.nationaljournal.com/2011/01/can-america-reach-obamas-clean.php.
44. President Obama's remarks on the economy, Winston-Salem, NC. Dec 6, 2010. http://www.whitehouse.gov/the-press-office/2010/12/06/remarks-president-economy-winston-salem-north-carolina.
45. Schneck, J., B.C. Murray, E. Gumerman, S. Tegen. 2010. "Estimating the Employment Impacts of Energy and Environmental Policies and Programs: Workshop Summary Report" Policy Brief NI PB 10-06, Nicholas Institute for Environmental Policy Solutions, Duke University. http://nicholasinstitute.duke.edu/economics/climatechangepolicy/estimating-employment-impacts/at_download/paper.

for a specific suite of technologies may not, by itself, lead to a large new domestic industry. Targeted tax credits and government-sponsored research, on the other hand, could potentially foster growth of domestic manufacturing.

Developing a robust set of policy options to improve U.S. competitiveness in the clean energy arena will require in-depth analyses in the following areas:

- technological assessment of options and where U.S. has natural comparative advantage;
- economic modeling of policy options to understand the impacts on covered entities and consumers;
- legal analysis of policy options (especially if involving trade policy and WTO issues); and
- assessment of critical supply chain factors, such as rare earth minerals (Indium, Gallium and Lithium) used in solar cells and advanced battery technologies, 95% of which are now controlled by China.[46]

46. Lacey, Stephen. "Rare-Earth Resources Increase Chinese Clout." Renewable Energy World.com. August 19, 2010. http://www.renewableenergyworld.com/rea/news/article/2010/08/rare-earth-resources-increase-chinese-clout.

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