SUSTAINING U.S.-CHINA COOPERATION IN CLEAN ENERGY

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Wilson Center

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Woodrow Wilson International Center for Scholars

Kissinger Institute on China and the United States

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WHOSE PATIENCE,
LOVE AND SUPPORT,
THIS BOOK WOULD NOT HAVE
BEEN POSSIBLE

INTRODUCTION

At the time of my initial appointment to the Wilson Center, it struck me that something was missing from the general discussion in the United States concerning China's embrace of clean energy and its implications for the United States. Much of what had been written embraced one of two polar positions. It seemed that the U.S.-China relationship in clean energy was either the best avenue for our cooperation or the measuring stick for our final competition. To a casual but concerned reader, the message was confusing. Newspaper "word-bites," rather than informing discussion, lent anxiety to the existing confusion.

The Woodrow Wilson Center provided me time and resources to examine the facts about clean technology ("cleantech") and China. This was timely. Government agencies, think tanks and trade associations hoping to influence the policy debate began in February 2009 to release a spate of lengthy and in-depth policy reports, many of them technical in nature. We will learn in Chapter One how and why that gusher of information—which has thrown up literally shelf-feet of reports over the past year and a half—suddenly arose. However, for the purposes of this Introduction, it is simply worth noting that these policy tomes, for all that they did serve to provide data-based context to what had previously been "context-free" highly combustible reporting, did not offer much help to an interested non-specialist in making better sense of the main issues.

At this "informed" end of the information spectrum, there was now almost too much information spread across too many specialized viewpoints. For a busy entrepreneur, investment manager, business professional, state or local government official, regional economic development analyst, scientific researcher, or engaged student—in fact, for any concerned "global citizen" wanting to understand the issues in a straightforward and streamlined way—it was famine or feast. A super-abundance of highly-specialized information provides not much more help in gaining an efficient grasp of the core issues than scattershot newspaper and media reporting had offered.

This book aims squarely at the "middle ground" of curiosity and interest in this broad topic. At the outset, I would like to be clear about three "operating assumptions" I have built in:

TIMEFRAME

The three main chapters are concerned with the three-year period from mid-2008 to mid-2011. Except for one digression involving Five Year Plans which covers a 30-year period, this limitation on perspective actually helps bring the main subject matter into better focus. The bulk of the U.S. political effort to engage with China in the clean energy arena took shape during the 2008 Presidential Campaign and was further framed through policy initiatives of the Obama administration. For a new industrial ecosystem like "cleantech" or clean energy, what is relevant is defined by what has most recently happened. It is only in the Conclusion that the time-frame is pulled back to show that some of the dynamics described in preceding chapters are, in fact, related to deeper and more long-standing trends in the overall U.S.-China relationship.

STRUCTURE

As author, I have insisted on an organizational principle for presenting information which puts me at odds with the conventional approach of "Beltway" experts. In Washington, the tendency is to run all relevant information through what I will call the "policy blender" and to present the resulting product as a mix of policy recommendation, policy analysis, and policy refutation. I take a different approach. I believe that the policy process is best served when the three main aspects of business-relevant policy are broken down and viewed separately in their own right. These are: (a) the politics underlying the policy process; (b) the technology innovations which policy initiatives aim to support; and (c) the investment ultimately required to take any technology innovation to scale in the marketplace, thereby driving policy on a long-term and sustainable basis. Rather than jumble these perspectives, I treat them in

separate chapters and try to adopt the relevant "mind-set" of each in presenting material in the respective chapter. This may be nothing more than a reflection of my former training as a cultural anthropologist, but I believe it is useful—within the complex arena of China, the United States, and energy—in revealing underlying dynamics. For this reason, in the U.S. section of the opening chapter on Politics, I will rely heavily on the words of key political actors. Ours is a system where the president needs to persuade the electorate and what is said matters. In the section on Chinese Politics, the approach is different, relying instead on "structural analysis" of the ruling party and its interests. In each case, the attempt is to adopt a perspective particularly suited to its subject matter.

PURPOSE

The Woodrow Wilson Center's motto is "knowledge in the public service." Woodrow Wilson epitomized the ideal of the "practitioner scholar"—the part-time scholar who devotes some of his or her career to bringing scholarly research into the practical, socially-relevant domains of government or business or non-profit work. This is the spirit with which I have written this book. I am neither a career academic nor a professional policymaker. I have tried to make this book clear and concise, although it involves a complex, and fast-changing topic. Especially for technically inclined readers, I want to acknowledge that no sector domain in the U.S.-China clean energy field can be adequately reduced to a couple of pages.

I believe this topic is an important one. If the United States and China find a way to realistically base and sustain their cooperation in clean energy, they will be addressing directly 40 percent of the world's total carbon emissions. And if together they manage to create a replicable model of cooperation, they can indirectly help the world address the remaining 60 percent. At its core, this topic touches everyone—those who care deeply about America's place in the world, those who are moved by China's epochal reemergence, those who are environmentally-engaged, and those who are

responsible global citizens. Students are a particularly important audience because the tectonic issue described in this book will ultimately be the felt experience of their generation.

In short, I hope that this book may be found to present important issues in a balanced way and to offer something useful and readily comprehensible to anyone with enough interest to pick it up.

POLITICS - U.S.

DRAWING A ROADMAP

In his 2008 book, *Hot, Flat and Crowded: Why We Need a Green Revolution—and How It Can Renew America*, Thomas Friedman highlighted clean energy innovation and technological cooperation as a way of rebuilding American global competitiveness and re-establishing U.S. global leadership. Prepped by China policy experts during that year's presidential primary campaign, each of the two leading Democratic candidates came to see opportunities for re-setting the U.S.-China relationship through this same prism of cooperation on climate change and environmental sustainability.

From the perspective of Democratic Party stalwarts, getting relations with China back on a positive track was long overdue. In their view, the Clinton administration had advanced U.S. interests and earned China's trust by re-introducing China to the global community, specifically through China's accession to the World Trade Organization (WTO). As prefigured by then Assistant Secretary of State for East Asia and Pacific Affairs, Ken Lieberthal, the plan had been simple:

> *As of late 1996, the Clinton administration anticipated important progress in U.S.-China relations during 1997. The benchmarks would be a visit by Vice President Al Gore to Beijing in the spring, the potential granting of permanent most-favored-nation (MFN) trade status to China during the summer, the relatively smooth reversion of Hong Kong to Chinese rule in July, and a head-of-state summit in the fall that would highlight agreement on China's application to join the World Trade Organization (WTO), the major global organization to set the rules for international trade.*[1]

From the Democratic Party partisan point of view, eight years of the Bush administration had accomplished precious little to build on this legacy. Yes, Treasury Secretary Hank Paulson was given credit for having succeeded

in institutionalizing an official "strategic dialogue" with the Chinese. But this difficult achievement had not yielded particularly noteworthy results. In fact, from the perspective of the Democratic Party's China specialists, the design of Paulson's structure had a critical flaw. Since all non-military aspects of executive branch policy toward China were being channeled through the Strategic Economic Dialogue (SED) under Treasury Secretary Paulson's chairmanship, there was an unhelpful tendency for all issues in the bilateral dialogue to run along a single track—the mano-a-mano contest over yuan/dollar exchange rates, for which the Treasury Department is primarily responsible. Despite a patient and strategic approach to build trust at the personal level, this focus yielded limited results on currency issues[2] and produced in the public mind a perception of zero-sum negotiations and a cycle of blame. U.S. negotiators would trace yuan undervaluation to China's structural over-dependence on exports and Chinese citizens' "oversaving" while China's negotiators would point back to U.S. government structural deficits and the excessive consumption of American consumers. (For the Republicans, this may have been a familiar re-playing of the Japan-U.S. relationship during the 1988-1992 period).

For the Democrats, a clear break with the past was required. First, there had to be a new vision. That vision revolved around the climate change problem, an issue that already had roots within the party's platform. Together the two countries account for 40 percent of global carbon emissions (as well as a comparably outsized share of other Green House Gas [GHG] emissions). As the largest historic and current emitters of carbon dioxide, the United States and China are seen by the world as being responsible for most of the negative impacts of climate change. Why not forge a partnership focused on correcting shared behavior that the world now deemed harmful?

The perceived opportunity lay in the possibility that the United States and China could bridge historical, cultural, and philosophical differences to forge collaborative leadership on an issue of global consequence. Such collaboration would need to extend across all the domains—regulatory, sci-

entific and research, technology, business and investment—and somehow converge if climate change were to be meaningfully addressed. In so doing, China would earn international recognition as a responsible stakeholder in the global system. The United States, in turn, would win a powerful partner for tackling a top national priority, would constructively reset its relationship with China in recognition of China's growing economic clout, and would rebuild American reputation after eight years of absence from the Kyoto Round and other global climate change initiatives.

To realize this vision, a specific plan and policy framework was required. As groundwork, several top think tanks joined forces and wove together strands of research and recommendations that had been years in development. The two seminal pieces of this effort were: (1) *Overcoming Obstacles to U.S.-China Cooperation on Climate Change* by the John L. Thornton China Center at the Brookings Institution and (2) *A Roadmap for U.S.-China Cooperation on Energy and Climate Change,* a partnership undertaking by the Pew Center on Global Climate Change and the Asia Society. Both were published in February 2009, the month of Barack Obama's inauguration as the 44th president of the United States. A third key study—the Center for American Progress' *Out of the Running? How Germany, Spain and China are Seizing the Energy Opportunity and Why the United States Risks Getting Left Behind*—was added in March.

Together, these and other[3] policy pieces provided the compass-needle for "the Roadmap"—the new administration's strategic plan to engage China cooperatively on environmental sustainability issues and, in so doing, to set the stage for a breakthrough in the global round of climate change talks. The first major test of this strategy was the upcoming global talks on climate change scheduled for Copenhagen in November 2009. That did not leave much time.

The first task at hand was basic housekeeping. The White House restructured and renamed the inter-agency process with China to emphasize the twin tracks of engagement. To underline this bureaucratic legerdemain, the name of the Strategic Economic Dialogue was tweaked to become the

Strategic *and* Economic Dialogue (S&ED). More consequently, the Dialogue was re-organized on a new co-chairman basis with Treasury Secretary Timothy Geithner chairing the economic component (with currency issues still the central focus of these talks) and Secretary of State Hillary Clinton chairing the new strategic track of an environmental/sustainability partnership with China.

In February 2009, as the first stop along this roadmap, Hillary Clinton took her inaugural trip to Beijing as Secretary of State. During that trip, Clinton generated some controversy among human rights groups when she made climate change, rather than human rights, the featured element of her agenda. To spotlight this move, she held a press event on the topic at the Asia Society in New York on the eve of her departure and included a well-publicized visit to an energy-efficient power plant joint venture between General Electric (GE) and a local Chinese partner during her visit.

In April 2009, Presidents Obama and Hu Jintao agreed to intensify policy dialogue and practical cooperation in energy, the environment, and climate change by utilizing the China-U.S. Ten Year Energy and Environment Cooperation Framework, established in 2008 at the tail-end of the Bush administration. They called for active cooperation in energy efficiency, renewable energy, and clean energy technologies and pledged to work with other states and international parties desiring positive results at the Copenhagen conference.

In May 2009, the first meeting of the reconfigured S&ED process took place in Washington, D.C. The urgent task of stabilizing financial markets and promoting recovery from the international financial crisis dominated the proceedings. Because this was the first high-level meeting between the two sides since President Obama's election, the new track of cooperative effort in the areas of climate change and clean energy did not feature prominently in official statements detailing the accomplishments of the meeting. Under the public surface, though, an effort to encourage convergence of the U.S. and Chinese positions in upcoming global talks through the build-out of a substantive bilateral partnership program was already underway.

GLOBAL TECTONICS

Bracketing the inauguration of the Obama administration in February 2009 were two tectonically-related global events.

The first occurred on September 15, 2008, when the initial upheaval of what would come to be called the Global Financial Crisis (GFC) was felt. This first tectonic wave came ashore at 745 Seventh Avenue in the Manhattan offices of Lehman Brothers.

The 2008/2009 financial crisis may have originated in over-leveraged U.S. sub-prime markets but it quickly spread worldwide. Following the dissolution of Lehman Brothers on that September day, the heaviest effects of the crisis quickly rippled out in the world's oil- and commodity-producing economies and in the export-led economies of Asia. In effect, the global recession represented a reverse gear of globalization. Sudden loss of confidence led to a seizing up of global credit markets, which in turn undercut global demand for manufactured goods from Asia's export juggernaut and, by extension, the oil and resources required to manufacture these goods. A feature of this "globalization-in-reverse" recession was that relatively insulated economies like that of Bangladesh experienced milder dislocation while newly emerging markets such as Eastern Europe and highly integrated markets such as Singapore underwent wrenching dislocation.

The economies of both the United States and China are deeply integrated into the global market, though at different ends of the globalization spectrum. China's economy is the "export machine" and "factory floor for the world," structurally oriented to marshaling its traditional global advantages of low-cost labor, land, and facilities for the purpose of supplying high-consumption markets worldwide with low-cost goods. The United States has been the high-consumption market for Chinese goods par excellence. The impact of the GFC was highly disruptive to both and each responded with massive stimulus programs to try to pump life back into their economies. We will return to these stimulus programs in Chapter Three.

Thirteen months later, an aftershock of the tectonic event triggered at Lehman Brothers was being felt in Copenhagen. At the global climate change talks (the UN-led COP[4] process), an effort was underway by the Obama administration to profile U.S. re-engagement with the process after an eight year absence via a global "cap-and-trade" deal. At the fulcrum moment, the U.S. and Chinese co-leadership plan faltered; Obama's outstretched hand was answered by a pointed finger.[5] The edifice of a global cap-and-trade system to create global pricing for carbon emissions was crumbling just as its former Republican advocates were pivoting to attack it.

In the aftershock of Copenhagen, two of the administration's policy initiatives were left buried in the rubble. First, the administration's commitment to a global cap-and-trade system under the joint leadership of the United States and China, was in ruins. Given Congress' rapidly darkening mood, it was clear there was little support on Capitol Hill for any effort to rebuild that particular edifice. A period of waiting and regrouping had started. Second, the cooperative track of engagement with China initially envisioned by the "Roadmap" had temporarily become a third rail. Traditional irritants in the relationship—many residing in the traditional political-military security arena as well as some new tensions around economic statecraft—were now eclipsing the strategic effort to build cooperation.

Sensing a downward spiral, explanations were offered to explain away the impact of the Copenhagen debacle on U.S.-China relations. Some pointed to the inability of Beijing "headquarters" to respond quickly, authoritatively, and with one voice to the terms of the proposed deal in Copenhagen. As a variant of this theme, some pointed to the relative inexperience of the Chinese diplomatic corps in managing sharp-elbowed, eleventh-hour, high-stakes global talks. As the dust was settling, the Chinese lead negotiator was transferred in a move widely interpreted as a demotion. Whatever the real cause of the failure was, it became lost in a cacophony of conflicting versions of events. In Washington, perception of a clear slight to the president took hold and soon defined the reality.

The administration now faced serious headwinds in its effort to engage China cooperatively in the global climate change challenge. Just nine months into its "Roadmap," the administration peered out at a collapsed global framework for addressing the climate change challenge, a strained partnership with China following their squabble on the world stage, and restive constituencies on Capitol Hill and throughout the nation questioning the stewardship of presidential authority. The "Roadmap's" reset of U.S.-China relations was now itself in need of a reset. At the same time, huge new battles over healthcare and the budget began to undercut hopes for a bilateral improvement.

PICKING UP THE PIECES

With its cap-and-trade strategy repudiated and post-stimulus political sands shifting, the administration avoided major energy and environment policy initiatives during the tail-end of 2009 and early 2010. During the 11-month period between the Copenhagen round of global talks in December 2009 and the U.S. midterm elections in November 2010, U.S. energy policy was largely stuck in neutral while U.S. relations with China underwent turbulent ups and downs.

Old Problems

What were these sources of turbulence in U.S.-China relations?

First, in the complex realm of conventional U.S.-China "high politics," the Obama administration started toughening its tone after Copenhagen. For the next four months after Copenhagen, a number of traditional irritants in the relationship resurfaced: Obama concluded the administration's arms sales deal to Taiwan; he met at the White House with the Dalai Lama; U.S. frustration with China's perceived failure to cooperate more fully on sanctions during Iran's post-election upheaval became obvious; and the simmering concern over undervaluation of the renminbi came to a boil again on Capitol Hill.

The confluence of these various tensions soon grew serious enough to require a measure of political calming down. This was accomplished in April 2010 when President Hu accepted, at the last minute, an invitation from President Obama to attend the nuclear nonproliferation summit in Washington, D.C. This summitry with other global leaders provided a brief interlude of positive feeling for the leaders of the two countries but, by early summer, two other long-time irritants in the relationship—North Korea and the South China Sea—were suddenly acute. The United States took issue with China's failure to take a firm line with an increasingly provocative North Korea. Then the United States responded sharply to Chinese "core interest" claims over a broad expanse of the South China Sea, claims which had echoes in Chinese history but were not well founded under the 1982 UN Convention on the Law of the Sea or in other touchstones of modern international law.

New Problems

Along with these embedded problems in the relationship, a new strand of dissension—tied to the "new politics" of economic statecraft[6]—was also weaving its way into established patterns of "high politics."

In the wake of the GFC and with U.S. efforts to jumpstart its sputtering economy, there was growing recognition of China's unprecedented success in wielding its economic power to reap the outsized political influence that had traditionally been generated only by hard power. The competitiveness and fair-trade concerns raised a year earlier by the Center for American Progress' *Out of the Running? How Germany, Spain and China are Seizing the Energy Opportunity and Why the United States Risks Getting Left Behind* grew increasingly public.

Throughout 2010, a new series of reports triggered further alarm. Among these were analyses that pointed to China's growing traditional industrial might and others concluding that, in the wake of the GFC, China had blazed past the United States to become the global leader in clean energy investment and finance.[7] Efforts to invoke trade remedies ensued. In

September, the U.S. Steelworkers Union filed a complaint against China to the U.S. government, citing numerous alleged unfair trade practices. In December, the U.S. Trade Representative initiated a dispute before the World Trade Organization over alleged Chinese subsidies to wind power equipment manufacturers, one of many issues contained in the Steelworker's omnibus complaint. By the U.S. midterm elections in November, attack ads targeting China were going viral in many congressional districts.

In January 2011, the United States made two additional moves related to clean energy on seemingly small stages that attracted big attention: Obama signed a new law containing a "buy American" provision for Defense Department purchases of solar panels and, for the first time, Export-Import Bank (Ex-Im Bank) of the United States moved to match its Chinese counterpart's below-market interest rates and easy repayment terms to support an export deal to Pakistan for advanced train technology from General Electric. The shadow of Copenhagen was lengthening.

Seeds of Cooperation

The re-tooled Strategic and Economic Dialogue process had gotten off to a low-key start with regard to public-announced cooperation between the United States and China but it did kick off substantial behind-the-scenes coordination. On the basis of the "roadmap process" and the earlier "U.S.-China Ten Year Framework Agreement for Cooperation on Energy and the Environment," a number of regional groups in both the United States and China were stepping forward with impressive programs. A public/private consortium group centered in Seattle, called the *U.S.-China Clean Energy Forum*, worked to identify priorities for cooperation and solutions to inform U.S.-China bilateral discussion. Similarly, a Bay Area-centric partnership, the *U.S.-China Green Energy Council,* drew on a network of University of California Chinese-American alumni—including, at its outset, Nobel Laureate and U.S. Secretary of Energy Stephen Chu—to organize conferences, mount exchanges, and help inform the new federally-led process.

Groups from the Chinese side also took initiative. One of the most notable was the *China Greentech Initiative*, an effort led by a former IBM alumnus to focus multinational corporations on the opportunities and challenges in China's environmental market. Another, the Joint *U.S.-China Cooperation on Clean Energy* (JUCCCE), achieved notable success in working with mayors throughout China and in establishing innovative programs of information sharing and exchange. Together, these programs represented the first generation of new "sub-national" linkages to support the national-level U.S.-China program of strategic engagement.

The Next Global Round

With all this swirling in the background and the Copenhagen debacle still a fresh memory, expectations were low for the next round of the global climate change talks, the 16th Conference of the Parties (COP) meeting, being held in Cancun from November 29 to December 10, 2010. Initially, China and the United States struck rigid poses that suggested they would not be able to move substantially beyond their prior impasse at Copenhagen. Xie Zhenhua, China's top climate change negotiator and vice chairman of the National Development and Reform Commission, insisted that the issue of developed nations financing climate mitigation for the developing world would have to be resolved before agreement on substantive obligations could be broached. U.S. Deputy Special Envoy for Climate Change, Jonathan Pershing was equally insistent that details on financing efforts to combat climate change could only be resolved after a basic agreement had been reached on measuring, reporting, and verifying the levels of carbon emissions reduction in developing countries. At the eleventh hour, however, the two sides suddenly moved toward compromise and a basic agreement for the 16th COP round was reached. Both the United States and China had backed down from their initial positions. This agreement, mixing watered-down versions of both the financing and verification ingredients, gave some new measure of life to the previously moribund prospects for U.S.-China global co-leadership to address climate change.

The "Shellacking"

While the Cancun outcome still remained to play out fully, the period of "gestation" described in this section effectively came to an end on November 3 when President Obama appeared at a press conference following the prior day's midterm elections. Describing the electoral results as "humbling," he acknowledged that he and his party had suffered a "shellacking."

The president clearly needed to come up with a new message for the American people in time for his State of the Union address two months away. First, though, he needed to study up on the lessons which the Clinton administration had taken away from its own electoral rout in the midterm elections of 1996.

SPUTNIK MOMENT

Two speeches, delivered within days of each other in early 2011, brought an end to the administration's previous year of inaction in the area of energy/environmental policy. Tellingly, the speeches taken together revealed Obama's takeaways from the 2010 midterm "shellacking" and previewed the thrust of a new, jobs-oriented stump speech being tested out for the 2012 campaign trail.

In his State of the Union address given on January 25, 2011, Obama dusted off some of the soaring rhetoric from his 2008 campaign and opened with two instances of overcoming adversity—the personal example of Representative Gabrielle Giffords fighting back from the brain trauma of her shooting in Arizona and the national example of Americans throughout history overcoming divisiveness to come together to act as a nation.

Barely two minutes into the speech, Obama then framed the central themes of his address: American innovation as the well-spring of high-quality jobs and the two principal challenges—"decades in the making"—to keeping high-quality jobs in the United States:

Many people watching tonight can probably remember a time when finding a good job meant showing up at a nearby factory or a business downtown.

That world has changed. And for many, the change has been painful.

The rules have changed. In a single generation, revolutions in technology have transformed the way we live, work and do business. Steel mills that once needed 1,000 workers can now do the same work with 100. Today, just about any company can set up shop, hire workers, and sell their products wherever there's an Internet connection.

Meanwhile, nations like China and India realized that with some changes of their own, they could compete in this new world. And so they started educating their children earlier and longer, with greater emphasis on math and science. They're investing in research and new technologies. Just recently, China became the home to the world's largest private solar research facility, and the world's fastest computer.

So, yes, the world has changed. The competition for jobs is real. But this shouldn't discourage us. It should challenge us.

After identifying the two facets of globalization which have had the biggest impact on U.S. jobs—the IT revolution in technology and the emergence of post-1982 China, along with India and other emerging economies such as Brazil and Russia (collectively known as BRIC countries), on the world stage—Obama returned to the American capacity for innovation.

Our free enterprise system is what drives innovation. But because it's not always profitable for companies to invest in basic research, throughout our history, our government has provided cutting-edge scientists and inventors with the support that they need. That's what planted the seeds for the Internet. That's what helped make possible things like computer chips and GPS. Just think of all the good jobs—from manufacturing to retail—that have come from these breakthroughs.

And then—taking the fullest possible advantage of the presidential bully pulpit in a nationally-televised address before a joint session of Congress—Obama invoked an existential challenge buried in our national memory:

> *Half a century ago, when the Soviets beat us into space with the launch of a satellite called Sputnik, we had no idea how we would beat them to the moon. The science wasn't even there yet. NASA didn't exist. But after investing in better research and education, we didn't just surpass the Soviets; we unleashed a wave of innovation that created new industries and millions of new jobs.*
>
> *This is our generation's Sputnik moment. Two years ago, I said that we needed to reach a level of research and development we haven't seen since the height of the Space Race. And in a few weeks, I will be sending a budget to Congress that helps us meet that goal. We'll invest in biomedical research, information technology, and especially clean energy technology—an investment that will strengthen our security, protect our planet, and create countless new jobs for our people.*

In case there was any doubt that the president was interested in singling out clean energy from other sectors, such as biotechnology and information technology, (which also drive innovation and create high-quality jobs), Obama then elaborated the special promise of the clean energy industry sector:

> *Already, we're seeing the promise of renewable energy…That's what Americans have done for over 200 years: reinvented ourselves. And to spur on more success stories like the Allen Brothers, we've begun to reinvent our energy policy. We're not just handing out money. We're issuing a challenge. We're telling America's scientists and engineers that if they assemble teams of the best minds in their fields, and focus on the hardest problems in clean energy, we'll fund the Apollo projects of our time.*
>
> *At the California Institute of Technology, they're developing a way to turn sunlight and water into fuel for our cars. At Oak Ridge Na-*

tional Laboratory, they're using supercomputers to get a lot more power out of our nuclear facilities. With more research and incentives, we can break our dependence on oil with biofuels, and become the first country to have a million electric vehicles on the road by 2015.

We need to get behind this innovation. And to help pay for it, I'm asking Congress to eliminate the billions in taxpayer dollars we currently give to oil companies. I don't know if you've noticed, but they're doing just fine on their own. So instead of subsidizing yesterday's energy, let's invest in tomorrow's…

Now, clean energy breakthroughs will only translate into clean energy jobs if businesses know there will be a market for what they're selling. So tonight, I challenge you to join me in setting a new goal: By 2035, 80 percent of America's electricity will come from clean energy sources.

It is easy to dismiss a speech, particularly a speech by a rhetorically-inspired politician, as just that. But several other facets of the game plan—all revealed in a burst during this period—combine to show a serious sense of purpose behind these remarks.

First, in the weeks surrounding the State of the Union, Obama had taken several highly-publicized steps to reposition himself with the mainstream of the American electorate and, especially, to repair the breach with the U.S. business community. On January 6, following Rahm Emmanuel's departure from the White House to run for the Mayor's seat in Chicago, Obama announced that his new Chief of Staff would be former Commerce Secretary Bill Daley, a respected and longtime advocate of business interests inside the Beltway. Next, on January 24, the White House confirmed that Carol Browner, the White House coordinator for energy and climate change policy, would be leaving the administration.[8] This was widely interpreted as a sign that the Obama administration now saw a need to scale back its push for regulatory-led change in the environmental arena and to switch to an approach based on partnership with the business community. Finally,

on February 7, Obama quite conspicuously buried the hatchet in his running feud with U.S. Chamber of Commerce president Tom Donohue and delivered his first talk to the Chamber—a fence-mending speech that was designed to find common ground for the "jobs agenda" he had laid out in the State of the Union speech.

On February 3, 2011, he took the additional step of traveling to State College, Pennsylvania to give a speech at the third of the new Energy Innovation Hubs, the only one he had not clearly identified in his State of the Union speech. This was to mark the new national center for energy-efficient buildings, headed by a leadership team at Penn State University and housed at the Navy Yard in Philadelphia.

Picking up where the State of the Union address left off, Obama first framed the challenge:

> *If we want to make sure that America is still a place where you can make it if you try, where you can go as far as hard work and big dreams will take you, then we're going to have to make some serious decisions about our long-term economic health—at a time when we're facing stiff competition from other nations for jobs and industries of our time.*
>
> *And I know every young person here feels that pressure. You understand that it's not going to be a cakewalk, this competition for the future, which means all of us are going to have to up our game. We are going to have to win the future by being smarter and working harder and working together. If we want those jobs and businesses to thrive in the United States of America, we're going to have to out-innovate and out-educate and out-build the rest of the world. That's what we're going to have to do.*

He then introduced the new, national-level Energy Innovation Hub for Energy-Efficient Buildings (also known as the Greater Philadelphia Innovation Cluster or "GPIC"), the third of the three regionally-based Energy

Innovation Hubs showcased in Obama's State of the Union remarks:

> *Now, this campus will be the product of a true collaboration. What, Penn State, you have done is develop an innovative model for how to do research. Government pulled resources from across different agencies to support your effort, from programs that train new workers and skills to loans for small businesses that will grow from your breakthroughs.*
>
> *Private sectors are already pitching in to help. So IBM is providing supercomputers. Bayer MaterialScience is providing materials for insulation and facades that save energy. PPG Industries is providing walls that reflect sunlight and windows that reflect infrared. Building this campus will support jobs in all of these businesses, and the discoveries made on this campus will lead to even more jobs—jobs in engineering; jobs in manufacturing; jobs in construction; jobs in installation; jobs in retail.*
>
> *And they'll be more than jobs that help support families; they'll be jobs with a national purpose. Jobs that make our economy smarter, jobs that make our planet safer, jobs that maintain America's competitive edge in the 21st century.*

At its core, the speech threw down a gauntlet for the 2012 election cycle, one which has been taken up in the recent national debate over raising the budget deficit ceiling. The speech, while addressing challenges from Asia, more directly confronted the idea in U.S. political debate that the government has no business supporting the market for renewable energy or, for that matter, the market for energy of any sort. In what sounded like rehearsal of campaign lines for 2012, the president challenged this. The government, like any household, needs to balance its budget. But balancing the household budget cannot come at the expense of buying textbooks for children in the household since supporting their future is largely the point of the household budget:

> *Now, just like Americans do every day, government has a responsibility to live within its means. But we also have a responsibility to invest in those areas that are going to have the biggest impact. And in this century those areas are education and infrastructure and innovation.*

The president, employing his bully pulpit to maximum effect, had taken the fight to develop clean technologies to the hoped-for wellspring of his future political support, the people. He may or may not succeed but the direction of the policy is clear. The national issue had now been re-framed: the "C's" of climate change and carbon were out and the "E's" of the economy (e.g., jobs) and energy efficiency were in. Internationally, clean energy competition with China had been invoked as the new prod for America in the 21st century, as the space race with the Soviet Union had been for the country in the latter half of the 20th century. In a democracy such as the United States, Obama had played his card the only way he knew, as an idea in need of public support. If I have dwelled at length on his words, it is precisely because policymaking in America requires this kind of public debate. Future cooperation with China cannot ultimately thrive without the debate being fully aired and decisive popular support coalescing behind the idea.

But now that I have tried to paint the American position going forward, it is time to look into the Chinese position, one less likely to hinge on the speech of a president.

ENDNOTES

1 Kenneth Lieberthal, "WTO, MFN, and U.S.-China Relations," *NBR Analysis-Promoting U.S. Interests in China: Alternatives to the Annual MFN Review 8*, no. 4 (July 1997): 23.

2 This process may have contributed to the 21.5 percent increase in the yuan's value against the dollar from mid-2005 to mid-2008, but the modest increase then stalled following the onset of the global financial crisis, effectively "re-pegging" the yuan's value to the dollar. Since June 2010, when Beijing allowed the yuan to resume modest movement against the dollar, the currency has risen an additional 7 percent.

3 See Appendix for suggested further reading.

4 In the nomenclature of the United Nations, COP refers to periodic "Conference of Parties" meetings within the overall United Nations Framework Convention on Climate Change (UNFCCC) process.

5 James Fallows, "What happened in Copenhagen, #4," *The Atlantic*, January 11 2010, http://www.theatlantic.com/technology/archive/2010/01/what-happened-in-copenhagen-4/33266/.

6 Ian Bremmer, Les Gelb and other commentators have drawn attention to China's "economic statecraft" and how it has changed the traditional power equation between the United States and China.

7 See the Pew Environment Group's Newsroom at http://www.pewglobalwarming.org/newsroom/articles.html for a listing of articles on the theme of "China overtaking the United States in clean energy investment" following the release of the Pew Environment Group's report, *The Clean Energy Economy* in March 2010.

8 This was all the more noteworthy because the handicapping going into the midterm elections had been that Department of Energy Secretary Stephen Chu, who had become a lightning rod for fiscal hawks on Capitol Hill, might bow out of his job and return to the University of California. Two dots that are easy to connect are the fact that it was ultimately Carol Browner who left the president's energy team in late January and that Obama then personally traveled to Penn State University on February 3 to champion Secretary Chu's Energy Innovation Hub program.

POLITICS - CHINA

SETTING THE STAGE

China's politics do not lend themselves to the same type of narrative just used in the American case. Politics in China are less about the personalities and programs of specific leaders. The contests to determine strategic national priorities are less transparent; instead, those contests are studiously kept from public view until they have been hammered out in party and government circles and can then be presented to the public ceremoniously in carefully staged settings. The Chinese process—as presented—is all black and white, without any of the gray tones helpful for fine-grained analysis.

Accordingly, we will use a different tack for this section on Chinese politics. We will try to look, *from the Chinese perspective*, at the two most important questions in any cooperative venture—what are my motivations, and what do I expect and want from this partnership effort? Brought into the specific domain of U.S.-China clean energy cooperation, these two basic questions expand into question sets:

1) What does "clean energy" mean in the Chinese context? Are China's leaders responding to the same idea of "clean energy" that the global COP process has shaped and which President Obama initially embraced? Or is there perhaps a particular "clean energy with Chinese characteristics" definition which is motivating them (and which the American partner might do well to understand)? If the latter, what are the unique characteristics of that definition and what then can realistically be expected from the partnership effort? As the Chinese expression so aptly describes, the situation of "same bed, different dreams" does not tend towards marriage fulfillment.

2) What do China's leaders ultimately aim to achieve with their clean energy policies—nationally, in the U.S.-China bilateral effort, and at the global level through the COP process? Is the goal cooperative, tied to global outcomes of social justice and environmental sustainability? Or

is it more narrowly and competitively conceived in terms of national advancement, possibly at the expense of other international players and even partners? If, as very well could be possible, both motivations are simultaneously present, how do they "fit together" into a broader motivational profile and what does that profile suggest for the prospects of a partnership effort?

In what follows, I will tackle both sets of questions. Although the goal of this monograph is more to pose the right questions in the right context than to furnish answers, the remaining sections of this chapter will offer some response to the first set of questions. The second set is more complex. Threads that tie together an overall skein to address this set of questions will be woven through the remaining chapters of the book. In the end, answers to this second set, though they must remain highly provisional, will be found in the Conclusion.

Energy Security, Environmental Insecurity

Any understanding of China's present-day security concerns requires an historical and cultural backdrop. This is true for the two specific security concerns we are trying to illuminate here: (1) China's effort to assure adequate energy supplies in order to maintain a trajectory of strong economic growth and (2) China's effort to manage the environmental fall-out of past and future economic activity so as to limit acute problems with the global community, key international counterparts, and China's own citizens.

To keep within the limits of our undertaking, I will just mention a few of the key referents which inform the "patterning" that is continually reinforced, linguistically and behaviorally, through cultural interaction[1] in China. These cultural patterns also inform the worldview of China's present-day leaders and give us a window into at least some of the motivations behind their policy initiatives. At the risk of oversimplification, key elements of this cultural patterning are:

- Although China has an expansive territory and the world's largest population, it is poor in most natural resources. The combination of large

population and a poor resource base has promoted instability throughout Chinese history. The ability of Chinese rulers to "hold together" their natural territory has frequently been compromised in this way. In short, the failure of past rulers to command an adequate resource base has led to "chaos" (which is the worst thing that the cosmos of "yin" and "yang" can throw at a society);

- For 13 of the last 15 centuries, China has produced the preponderance of the world's wealth.[2] As recently as the 18th century, China accounted for one-third of the world's economic activity. China's economic rise within the world community over the past three decades is neither an historical aberration nor an economic miracle. It is simply tracing the trajectory of China's return to its "rightful place" among nations;

- China's weakness on the world stage in the 19th and early 20th centuries is a cause of abiding shame for all Chinese. One cause of the weakness was victimization of China by foreign colonial powers. Another cause of the weakness was China's own failure to recognize the power of science, applied through technology, to economic betterment;

- The Chinese will learn from their mistakes. They will approach the opportunities presented by the 21st century with national pride (and avert their eyes from the mistakes of the Great Leap Forward, the Cultural Revolution, et cetera). They will never again endure humiliation at the hands of foreign powers. They will never again miss one of the industrial revolutions which have been propelling human development, in faster and faster waves, over the past 150 years—from steam to oil, electricity, telegraph, internal combustion engine, computers, biotech and now clean energy.

With the benefit of this broad, culturally patterned background, the energy security and environmental dilemmas facing Beijing's leadership resolve into some very fundamental challenges. As we will see in greater detail in Chapter Two, China's dependence on imported oil has skyrocketed since the early 1990s. China's own on-shore and off-shore oil production has

been faltering and, within just a few years, China will be importing a higher percentage of its oil than the United States. As we will also see in Chapter Two, it is not even remotely feasible that China's foreign oil dependency could be fully offset through the expansion of renewable energy sources any time in the foreseeable future. The scale of China's oil dependence is too great, the demands of growth too voracious, the level of installed renewable energy capacity too infinitesimal, and the barriers (both in terms of technology and capital requirement) to renewable energy ramp-up too great for this to be considered. Even domestic natural gas, while promising, offers scant prospect of significantly alleviating the problem.

So, in the energy domain, China faces an "everything-and" type of challenge. In order to limit its growing dependence on foreign oil (and to avoid the cultural "neuralgia" associated with issues of resource inadequacy, foreign dependency, loss of political control, fear of chaos, et cetera), China has to do *everything* in its power and even that may not be enough. It needs to complement vulnerable maritime routes of oil importation with less vulnerable land-based pipeline routes. It needs to build out its relatively weak natural gas sector and exploit its newly discovered reserves of shale gas. It needs to keep forging ahead with nuclear energy development, despite concerns raised for the industry by the Fukushima disaster. It needs to develop renewable energy sources—not just one or two types on a hit-or-miss basis, but every renewable energy sector across the board developed to the maximum extent of technological and financial feasibility. Finally, and importantly, it needs to find a way to continue its heavy reliance on "dirty" but cheap coal, currently the source for over 70 percent of China's electrical generation. And it must do this at a speed that meets the needs of an economy growing by 10 percent annually and a growth in consumer demand and material expectations many times that rate.

In the eyes of China's leadership, the one paramount issue in securing adequate energy supplies for China's continued economic growth is not the *type* of energy, but its *location*. Energy of virtually any type sourced within China is good, from outside of China is bad. As a senior energy policy official in China has said, "energy supply should be where you can plant your

foot on it." From this standpoint, renewable energy, domestic coal, shale gas, and nuclear power are all rising stars. Oil, given shrinking domestic rates of production and growing foreign dependence, is a sunset industry.

Why do China's leaders feel that the 30-year pace of breakneck economic development cannot now be slowed to a more moderate level? The simple answer is China's demographics. A long-term fertility decline[3] coupled with the introduction of China's one-child-per-couple policy in 1979 mean that China is now undergoing an inversion of the standard "productivity pyramid" (whereby a broad base of economically-active adults support a smaller "apex" of elderly adults no longer actively contributing to national productivity). In China's case, the number of people in the 20 to 24 year old bracket is projected to drop from roughly 120 million to 80 million over the next 20 years at the same time that the number of people over 65 will be doubling from approximately 120 million to 240 million.

A reason for the obstinacy shown by Chinese negotiators in rejecting out of hand Western demands for renminbi (RMB) appreciation or coal-economy cutbacks is this demographic ticking clock. Without an established social safety net for its citizens, China's leaders are intent on maximizing China's wealth now before demographic pressures are more fully felt. The concern lurking behind China's economic and energy policies is the question "will we get old before we get rich?"

Looked at from the perspective of China's leaders, the overriding priority is to assure sufficient amounts of domestically-based energy to meet the country's needs over the next decade or two. As we will see in the next section, China also has real concerns about global warming and the potential impact of climate change on the country's well-being and has meaningful policies[4] in place to try to address this. Similarly, Chinese leaders have genuine anxiety about the "residue" from the rampant growth since 1982 that exists in the form of widespread pollution across China and are taking steps[5] to address that as well. However, both problems are seen in Beijing as problems with a longer fuse, letting their associated "motivations" show up as a "second-order" concern in the policy formulation process.

While secondary, these concerns nonetheless do nag at Beijing's leadership. What if their "second-order" efforts—to appease the global community in the COP process and to appease their own citizens protesting against pollution in their backyards—were to fall short? What if the global community "ganged up" on China in the COP process and managed to put the brakes on China's plans for coal development? What if the same type of anti-pollution fervor which helped trigger democratic reforms in Taiwan were to jump the Taiwan Strait to the mainland? In all these cases, they would see risk to their paramount enterprise–maintaining the smooth and powerful takeoff of China's economic ascent and, in so doing, ensuring the continuity of the Chinese Communist Party at the controls.

Managing Hyper-Growth-Part I

Somewhere between 2009 and 2010, China overtook the United States in *both* total energy consumption and in total carbon/greenhouse gas (GHG) emissions. Therein lies a global story.

From 1949 until 1982, China was virtually off the global grid for "modern" economic activity and its concomitants of carbon-based pollution. It fell to Deng Xiaoping, following Mao's death, to begin in 1982 a series of market-opening reforms, ushering in a reintegration of China into the Western-led global economic system.[6]

The Management Challenge

Success needs to be managed. In the three decades since Deng's market opening in the early 1980s, China has achieved colossal economic strides forward. Over this period, China has come from almost a zero-baseline to become the world's fastest-growing major economy, with average growth rates of 9.8 percent over the past three decades. During this period, China also became the world's largest exporter and its second-largest importer, behind the United States. In 2010, as noted above, China became the top energy consumer in the world. In 2011, China became the world's top manufacturer. In both cases it did so by surpassing the United States. These results have come from less than 30 years of sustained effort.

One element (and perhaps goal) of the Chinese Communist Party's (CCP) management of this remarkable global story has been to use it themselves with domestic constituencies to bolster their own legitimacy. After jettisoning various stages of the Marxist rationale for party control in 1982, 1992, and 2000[7] this narrative of success has become the tap-root of post-reform legitimacy for the CCP.

Another element of the management challenge has been to try to limit risks associated with the super-sized environmental costs which have been a by-product of China's extraordinary economic growth over this period. The circle which Chinese leaders are trying to square is to overhaul their growth model to make it sustainable, environmentally as well as in other ways, while not impairing the sustainability of their own power base.

The Chinese leadership routinely uses three highly-geared levers of power to this end. First, it strictly controls the messaging and public awareness about environmental problems in state-controlled media and is still attempting to do so with a newer generation of more free-wheeling media. Second, it uses its entire range of personnel tools for party and professional advancement (as well as the threat of demotion) for the government "managers" of these problems. Finally, even a third lever of power—the People' s Liberation Army (PLA)—is sometimes activated, such as during the clean-up action at Lake Tai in the lead-up to the Olympics. More generally though, the PLA is expected to stay in the background while local police authorities manage local disturbances[8] triggered by pollution incidents tied to industrial malfeasance, land misappropriation, governmental indifference and/or collusion, and the like.

The Structure

An irony of the Global Financial Crisis (GFC) is that its financial exigency forced two very different economic systems to act, publicly and privately, as if they were in step. The stimulus packages rolled out by both national governments as response to the crisis provide a good example of the public effort. But the pas de deux is awkward. The two partners find themselves

in the global spotlight together but there are questions concerning who is leading and, in any case, they have different ideas about which dance they are dancing. To realistically gauge the possibilities for U.S.-China co-leadership of the global climate change problem, systemic differences between the two countries need to be understood.

Most any educated Chinese can recite the basic features of the U.S. system: that it is based on a separation of powers between church and state and, governmentally, between the legislative, executive, and judicial branches. A complex system of checks and balances—essentially, processes to scrutinize, hold accountable, and limit the exercise of power by individual actors and organizations within this system—is built in to its functioning by its Constitution and laws, which in turn must be reviewed and upheld by the courts. Extended into the economic sphere, a related concept of separation—between the public sector (government) and the private sector (markets)—applies. Private-sector actors—whether corporations or individuals—buy and sell products and services in the marketplace and bid for various money instruments and company ownership transactions in the capital markets. Government is expected to stay aloof from this process, leaving it to profit-motivated specialists in each of these commercial areas to stake private funds and help determine ultimately the market's winners and losers.

Most Americans, irrespective of their education, are correctly less than confident that they understand the basic outlines of China's present-day political and economic systems. What does party control over the state mean for China in practical terms in 2011? Is a party which has jettisoned the Marxist bedrock of its legitimacy still "Communist?" Most importantly for our purposes in this book, who is actually controlling the marketplace now that China has joined the WTO and economic growth has become such a large part of its national purpose?

To help us discern what underlies China's drive for energy security and understand what motivates its environmental program at the national and international levels, we will start with these broad-brush outlines. First,

while China may no longer be ideologically Marxist in outlook, it is still decidedly Leninist in terms of how the CCP maintains its hold on power. The most important levers of power remain, as thoroughly described by Richard McGregor, "the three P's—personnel, propaganda, and the People's Liberation Army." (Less explicit, but still vitally important as we will see, is the party's control of the marketplace). Second, when our governments negotiate, the apparatus of the U.S. government is reporting to a president who keeps Congress informed and it is ultimately accountable to the electorate. This is why his important speeches and their congressional reception matter. In China, the apparatus of Chinese ministries takes direction from, and reports back to, the State Council and on to the largely figurehead National People's Congress, both of which are ultimately accountable to the Chinese Communist Party, rather than to the Chinese people. For most purposes, then, China's government in 2011 remains "Communist" although the basis of its appeal for legitimacy in the eyes of the Chinese people has changed dramatically over its 90 years of existence. The CCP's justification is no longer a dialectically-ordained triumphant future governed by objective laws of history and class conflict, but now a more backward-looking and imprecise suggestion: "Who else could have delivered the economic goods to China than the CCP?"

Precisely because the basis for CCP legitimacy, and its continued hold on power and even existence, depend on delivering the economic goods, CCP control of the marketplace remains vitally important. Americans witnessing China's accession to the WTO may have assumed that the days of CCP control over its marketplace were numbered and that internationally-based norms of market control would curtail its role. It is entirely possible that the CCP leadership saw it differently. They may have been acting on a short-term calculus to maximize the near-term economic benefits of entry into the World Trade Organization while wagering they could delay until the longer-term future a reckoning over who would ultimately have market sway.

SASAC

A quick look at the State-Owned Assets Supervision and Administration Commission (SASAC) will shed some light on how the party manages the role of state-owned enterprises (SOE) in the Chinese economy. The SASAC is the instrument through which the Chinese government apparatus controls its interests in the market economy. While China specialists who had paid attention to the SASAC generally expected its influence to wane over the decade since China joined the WTO, the opposite has, in fact, happened:

- China's SOEs have, over this period, consolidated and expanded their market share through acquisition of domestic entities, government-led strategic restructurings, and increasingly assertive moves to "turf out" powerful foreign competitors in the domestic market;[9]

- Chinese government holdings in the SASAC have been increasing more than 10 percent per annum in recent years and the state is strengthening its role both as a financial backer for these enterprises and as the drafter of preferential policies which favor their growth;

- To better position SASAC companies in certain sectors to withstand global competition, SASAC has organized them into cooperative associations and the government has encouraged them to develop standards that can be introduced for the domestic market and internationally;

- Over the first three quarters of 2010, sales of all state-owned companies rose more than 35 percent relative to that period in the prior year. Overall profits exceeded 30 percent (3.99 trillion yuan reported on sales of 12.6 trillion yuan). Meanwhile, the government continued to groom some of its best talent, on elite tracks of education and career development, for posts managing SASAC-controlled companies;

- While the Chinese economy continues to diversify, many strategically important sectors like oil, civil aviation, telecommunications, electrical

distribution, and banking are entirely dominated by three, four, or five state-owned companies. Within these sectors, it is not unusual for the Central Organization Department (see next section) to transfer around the Chairmen and CEOs between nominally competing companies. From a CCP perspective, this broadens the experience of high performers, both rewarding them and potentially grooming them for expanded responsibilities in the future. Simultaneously, it helps maintain a clear demarcation where the executive's loyalties properly reside.

Managing Hyper Growth-Part II

We have looked briefly at the SASAC, the organizational tool which China uses to manage its state-owned assets in the oil, coal, gas, nuclear, and renewable energy sectors. We will now look at China's primary planning tool for its economy—the Five-Year Plans (FYP). The FYP economic planning process was initially introduced to the Soviet Union by Stalin[10] in 1928 and then brought to China by Mao Tse-tung in 1953. Despite all that has happened in the world since then—the 1960 rupture between China and the Soviet Union, the disintegration of the Comecon economic bloc and eventual collapse of the Soviet Union, and the abandonment of Marxism in China in favor of "capitalist"-style economic reforms—Five Year Plans have remained an unchanging feature of the Chinese economy.

The Plan

The scope of the national transformation undertaken in China over the last 30 years has been breathtaking. From a U.S. perspective, it has all been hidden in plain sight in successive FYPs. To appreciate the importance of FYPs for the development of China's clean energy economy, a quick glance over three decades of nationally-directed, strategic development helps establish perspective.

In 1979, as a prelude to the introduction of economic reforms, a county of small fishing villages across the border from Hong Kong was promoted in that year to prefecture level and then, in 1980, renamed "Shenzhen" and

formally inaugurated as the nation's first "special economic zone" (SEZ). The idea behind this experiment—to attract industrial investment from nearby Hong Kong to a controlled zone of "Hong Kong-like" investment conditions with direct access to lower-priced Chinese land, labor, and facilities—took hold. Over the next two FYPs, Shenzhen was a principal beneficiary of nationally-directed investment funding. From 1982 to 2010, its population grew 30-fold, from 350,000 to 10,350,000; over the same period, its economy has gone from "negligible" to the 102nd rank in the Globalization and World Cities Research Networks' "Global Cities" ranking (putting it in the same "Gamma" category as Perth, Antwerp, Philadelphia, and Portland).

The success of the Shenzhen undertaking encouraged national planners to reprise the strategy in the 1990s, following the country's initial economic slowdown in the wake of the Tiananmen incident. Administrative control over a largely agricultural area across the Huangpu River from downtown Shanghai was reorganized and then, in 1993, designated as a new SEZ (with its western tip further designated as a finance and trade zone). Over the space of 20 years, this area—Pudong—has become home to some of the tallest office buildings in the world and now boasts an economy roughly equal to the national GDP of Slovenia.

Bringing the focus back to the present day and China's on-going effort to develop a clean energy economy, the coastal city currently in the spotlight for nationally-directed development through the FYP process is Tianjin, located just 112 km east of Beijing on the Bohai Bay in northeastern China. Under both the 11th (2006-10) and 12th (2011-15) FYPs, Tianjin has been designated as China's national test-bed for the deployment of clean energy technologies as well as for experimental mechanisms[11] of raising private capital to support investment in clean energy and other experimental technologies.

In the very "big picture" sense of three decades of globalization, one can view these plans like memos to organize a retail store's sales effort at peak buying season. (Think Saks Fifth Avenue at Christmas time.) China's economic development strategy has always hinged on foreign investment—in

other words, they recognize that they need buyers. Without sufficient funds to develop the country on its own, China's leadership has always clearly seen the need to lure investors in. The retail strategy for doing this is a showcase window, one that stops pedestrians on the sidewalk, causes them to gawk, and—through the crowd effect—creates the sense that, by moving on, something important would be missed. The three showcase cities[12] of Shenzhen, Pudong, and Tianjin have served, in astutely planned fashion, exactly that function for "China Inc." As any merchant knows, a customer cannot put money in your cash register if they are standing on the sidewalk. A showcase window, though, can bring them through the store's doors and, once inside, the odds are high that they will leave money behind.

None of this requires a specialist's insight, though more than one specialist has missed the relative importance of this largely predictive process. It has always been laid out for the world to see in China's FYP planning documents. If it has not been widely recognized, it may simply be because the breadth and boldness of vision is unlike what the West has come to expect from its policymakers. The planning has been announced and implemented like clockwork: Shenzhen on the southern coast under the 6th, 7th, and 8th FYPs; Pudong on the central coastline under the 8th, 9th, and 10th FYPs; and now Tianjin on the northern coastline under the 11th and 12th FYPs. Nor is the Chinese vision intended just to benefit the "showcase" cities themselves. Each of the cities is located on one of China's major water systems—Shenzhen on the Pearl River, Pudong on the Yangtze, and Tianjin on the Bohai Bay. The explicit goal is that the twin benefits—first, of the central government's "dressing up" the showcase city and, secondly and more importantly, of the new showcase city attracting substantial foreign direct investment—will create commercial dynamism that will spread beyond the showcase city itself and move, along traditional water-based commercial pathways, to benefit entire hinterland regions in the south, central part of the country, and the north. It is a bold plan which continues to work.

"Eco-Preneurship" and Bureaucratic Control in the Chinese Context

Arguably, it may be working too well right now for China's long-term economic interest. The success of the FYP planning process, together with the SOE ownership structure (see above) and the CCP's personnel management system (see below), have created something of a casino mentality for local government-led "eco-preneurship" that poses threats to the balanced, long-term development of the clean energy industrial sector.

To assert that something as evidently successful as China's 30-year FYP playbook may have become problematic is a big claim. The component parts of the assertion should be unbundled and examined more closely. We already have some sense of the structural tendencies inherent in the CCP's ownership and management of SOEs through the SASAC. Before describing what is meant by the "casino mentality for local government-led 'eco-preneurship,'" let's look at another feature of China's management system for hyper-growth: the role of the Central Organization Department (COD). An organization of almost comparable importance to the PLA in maintaining the preeminence of the Chinese Communist Party, the Central Organization Department makes a point of keeping itself out of sight. Here is how Richard McGregor begins the chapter devoted to it in his book *The Party*:

> *The national headquarters of the Central Organization Department occupy an unmarked building in Beijing, about a kilometer west of Tiananmen Square along the broad sweep of Chang'an Avenue. No sign hangs outside indicating the business of the building's tenant. The department's general switchboard number is unlisted. Calls from landlines in the building to mobile phones do not display an incoming number, as is customary for ordinary phones, just a string of zeros. The only way a member of the public can make contact with the department in Beijing is through its sole listed number, 12380, which has a recorded message, allowing the caller to report any "organizational" problems above the county level.*[13]

So, in short, the COD manages a vast HR department for China Inc. Big city mayors, governors and party secretaries do not, by necessity, work their way up a local ladder. They are parachuted in by Beijing for a fixed term, expected to perform the national government's bidding, and then either rewarded, sidelined, or punished for their performance with their next assignment.

Until quite recently, 100 percent of the COD's "performance appraisal" for its personnel was based on criteria of economic performance. However, in step with the growing recognition that untrammeled economic growth was leading to almost boundless environmental spoilage, the appraisal system was recently re-jiggered. Although the secretive nature of the COD makes it difficult to know or show precisely, the general understanding is that the COD's assessment system is now based roughly at a 70 percent level for demonstrated ability to improve economic outputs and at about 30 percent for their ability to advance environmental objectives.

This raises an issue which we will examine more closely in the chapter on investment. But let us pause for just a moment to consider here the built-in propensities of the system we have described so far. There has been an average of 9.8 percent growth per annum over almost 30 years. Ideals of social justice have been left behind as a value-system of economic advancement takes hold. Some career pathways have opened up in the private sector but control over the private sector remains firmly in government hands and that government has been acting decisively in recent years to promote the interests of state-owned companies at the expense of Chinese private sector companies (not to mention foreign firms). Career advancement within the government and, more importantly, within the Chinese Communist Party hierarchy, remains the surest and usually still the most lucrative, career ladder. Finally, the rules for playing chutes-and-ladders within this career system have recently changed to partially reward environmental initiatives.

Any student of organizational behavior could predict some of the most obvious outcomes of a system structured on this basis with this incentive

structure. The particular outcome to highlight for our purposes is perhaps not among the most obvious but is nonetheless striking. An organizational behaviorist studying this system would probably anticipate a sharp rise in the number of risk-taking, ambitious young leaders taking a tactical focus on projects which simultaneously promise to yield both economic and environmental performance indicators. This is, in fact, what is happening on the ground in China. There is an entire new cohort of "eco-preneurs"—ambitious incumbents of coveted governmental positions who are using governmental budgets (at the national, provincial, and prefectural levels) to advance a whole host[14] of "green-, eco-, low-carbon-, zero-carbon-," and like-minded initiatives. While perhaps immediately commendable on the surface level (and in performance appraisals), there are some basic grounds for caution when considered over the medium-term. How economically successful will these projects be if China's GDP growth rate were to be halved to "just" the 4-5 percent range? Should it be a cause for concern that the barrier for entry of investors into the cleantech sector is generally much lower than IT, biotech, nanotech, or other advanced industries? What does this situation portend for a system recognized as unable to account properly for national-level lending to the local level? How many of these projects have a real estate underpinning that would disappear should the Chinese "real estate bubble pop?"

In the background of these questions is the currently vexed issue of financial sustainability at the national and global levels. For all that China now lectures the United States about its irresponsible levels of external indebtedness (which are now approaching 100 percent of the country's GDP for gross debt and approximately 60 percent of GDP for public debt), China's debt levels may well be at comparable levels (relative to their GDP) but far less transparent. One reason for the non-transparency is that a large portion of the debt position of China's national government is cloaked in off-the-radar transactions with local government entities. Another is the more muted style of citizen debate about their government's actions and priorities.

We will examine these questions in greater detail in Chapter Three. For now, let us return to a consideration of how all this stacks up for China's self-conscious positioning on the global stage and, particularly, for its awkward, spotlighted dance with the United States to the tune of global sustainability.

GROWING PAINS

In the economic realm pertaining to U.S.-China clean energy relations, the United States and China find themselves once again on the global stage. Unfortunately for both of them, though, conditions on the dance floor have deteriorated and their ability to move to the music has grown constrained. After 30 years of all-out pushing, China has achieved more than anyone could have predicted. But persistent inflation, labor and energy cost challenges, and still continuing pressure for RMB revaluation constrains her room to maneuver. Meanwhile, the global stage feels diminished—China now on the horns of a dilemma (that its economy either overheats or has a hard landing), America in political gridlock, Europe in currency free fall and the whole global economy peering at the prospect of a double-dip recession. At the same time, China is focused on re-balancing itself to cope with rising demands for accountability and transparency from its own people, to restructure its efforts away from its current extreme dependence on export markets, and to manage the challenge of demographic imbalance and a rapidly aging population over coming decades.

Meanwhile, the anemic performance of the U.S. economy, coupled with the spectacle of near U.S. gridlock in its budget deficit debate and the subsequent downgrading by the credit-rating agency Standard and Poor's (S&P) have prompted the Chinese to question, for the second time in three years, just how attractive the United States is as potential partner. Their global dance suffers as a result of these doubts.

Nevertheless, some progress was registered over the past year.

The Cancun Round of the COP process yielded better results than many had thought possible. During his January state visit to Washington, Hu

also took pains to show the "smiling face" of Chinese "peaceful rise" diplomacy, replacing the "angry face" that had been on view after the Nobel Peace Prize award was presented to Liu Xiaobo and a series of incidents in the South and East China Seas. Hu also skillfully brandished "China Inc.'s" checkbook, presiding over the sealing of more than US $45 billion worth of commercial deals during his visit, with fully one-quarter of that amount going to clean energy deals with major U.S. firms. In negotiations during the state visit, China also appears to have ceded ground in the highly-charged dispute over China's "indigenous innovation" policy in government technology procurement (which U.S. critics saw as disadvantaging U.S. providers or pressuring them to transfer intellectual property rights to Chinese firms).

This two-step of assertive, then more ingratiating, behavior by the Chinese lends some hesitancy to the dance of cooperation with the United States. Real ambivalence lies behind it for China. On the one hand, as Elizabeth Economy, Director for Asia Studies at the Council on Foreign Relations, has well described, China holds a bold vision of itself moving toward global center stage. It plans to raise its profile among global mass media to more actively shape the world's view of events; to act with determination in reshaping the rules of international and global organizations in line with its interests; and to defend more aggressively China's supply lines, energy interests, and maritime claims throughout the world. Fitting in with this pattern is also the active encouragement by the Chinese government of their state-owned companies to "go global" and to acquire overseas holdings as a more economical use of their budget surpluses than recycling in U.S. bond markets.

On the other hand, China has vested interests that argue for a more docile approach in line with a historically-grounded attitude of deference to U.S. power in the wider world. Despite occasional talk in China of "passing the USA" in favor of deepening commercial ties with the BRICs and other fast-growing developing markets, Chinese state-owned companies know that this is not an option. They know they cannot become world-class if

they do not acquire global market experience and global management skills. Access to U.S. markets provides an indispensable proving-ground. Chinese state-owned and private manufacturers depend on sales to U.S. markets in key areas, including, in the clean energy sector, photovoltaic solar products. They need U.S. markets to grow while they wait for a domestic market to be developed.

Back in China, public attitudes are deeply confused by all the talk they hear from U.S. sources about "Sputnik moments" and about the U.S. feeling challenged by the global race with China for 21st century energy. In their minds, innovation is in the U.S. market's DNA and is the most notable feature missing from the Chinese market. The notion that Chinese innovation is an existential "Sputnik-" like threat to the United States thus does not describe for Chinese observers a recognizable reality. That such Chinese "innovation" might be seen as a rallying cry for U.S. action taking a tougher line against, and seeking to outcompete, China in clean energy and other innovation-intensive sectors is even more alarming to the Chinese public.

Adding to this swirl of impulses is the background chorus of concern that China's Open Door policy for foreign direct investment in China may be swinging shut. That chill in the air is matched by the tightening controls in China over social media in the wake of the Arab Spring. Premier Wen Jiabao took pains to dispel the former concern with his recent announcement of several dozen market openings for foreign firms but these reassurances were generally deemed unconvincing because they applied to government-protected sectors which no foreign firm would lightly set foot in.

The United States' tougher tone in the traditional politics of bilateral relations and in the new politics of economic statecraft has not tripped up U.S.-China cooperation in clean energy or triggered a combative competitive response from China. If anything, it seems to have given China's leaders a reminder of the traditionally assertive "role" of the American presidency. China has, in small steps, come to see Obama as dancing to an established and recognizable "American tune" on the global stage and has, at least to some extent, adjusted its footwork accordingly.

From February to November 2009, the Chinese side had conspicuously refrained from reciprocating or accepting Obama's initial open-hand gesture. In hindsight, it is not surprising that their encounter got off to an awkward start. None of the preceding four generations of Chinese leadership has greeted a new U.S. presidency with an attitude warmer than extreme wariness. Given Barack Obama's exceptional personal story and his youth, the less-than-youthful and risen-through-the-system leadership in Zhongnanhai was perhaps even more wary. They were dealing with a particularly unknown quantity and chose to ignore the proffered hand. At the time, the two sides did not have a sufficient shared understanding of what U.S.-China bilateral global leadership on the clean energy issue would look like. Before he recast it as an American jobs-creation and "winning the future" issue in his January 2011 State of the Union speech, Obama had treated the climate change issue primarily as a moral imperative for U.S. global leadership and as a means to help repair eight years of damage to U.S. leadership and working relationship with the UN and other multilateral organizations. The Chinese leadership, on the other hand, has consistently viewed the clean energy issue almost entirely through the lens of national energy security and as vital to maintaining China's economic growth and the Chinese Communist Party's political legitimacy. With the two sides acting from such different motivations, a working partnership based on—"one bed, different dreams" as the Chinese proverb puts it—could not have been expected to develop quickly or perhaps, at all.

Given new challenges in mid-2011 occasioned by the bruising domestic budget battle in the United States, the plunging creditworthiness of an increasing array of European nations and the volatility of world markets and commodity prices, forging a new and ambitious collaborative bilateral relationship in this highly charged, highly competitive atmosphere will not be easy.

ENDNOTES

1 To be more accurate, these inform Han-to-Han cultural interactions in China.

2 Ian Morris, *Why The West Rules – For Now* (New York: Farrar, Strauss & Giroux, 2010), chap. 7.

3 See various articles by Feng Wang, Director of Brookings-Tsinghua Center for Public Policy.

4 These include a 40-45 percent reduction in carbon intensity by 2020; a 15 percent contribution by non-fossil fuels in the mix of primary energy consumption by 2020; and a 16-17 percent reduction in energy intensity by 2020. See pages 67-68 in "Rising Tigers, Sleeping Giant" by the *Breakthrough Institute* for a chronology of major laws to this effect.

5 See *Challenges and Opportunities for U.S.-China Cooperation on Climate Change*, Hearing before the U.S. Senate Foreign Relations Committee (June 4, 2009) testimony of Elizabeth Economy, C.V. Starr Senior Fellow and Director of Asia Studies at the Council on Foreign Relations.

6 With the collapse of the Berlin Wall and the Comecon economies in 1989, China found itself needing to bolster its new orientation to the global economy and Deng Xiaoping achieved this with his historic "Tour of the South" in 1992.

7 Corresponding to Deng Xiaoping's introduction of economic reforms, his Tour of the South speech, and Jiang Zemin's Party Anniversary speech advocating that private business be allowed to join the Chinese Communist Party.

8 These protests are not insignificant in either scale or number. In August 2011, 12,000 demonstrators protested against a new paraxylene production facility owned by Fujia in Dalian. This was a reprise of another large-scale protest against another producer of the same chemical in Xiamen in 2007. Although of generally much smaller scale, some 180,000 protest incidents of this sort took place in China in 2010. See Sharon LaFraniere and Michael Wines, "Protest Over Chemical Plant Shows Growing Pressure on China From Citizens," *New York Times*, August 15, 2011, http://www.nytimes.com/2011/08/16/world/asia/16dalian.html?pagewanted=all.

9 Carlyle Group's failure over three years to achieve a tie-up with state-owned machinery maker Xugong is one of many illustrative cases.

10 Following the "New Economic Policy" formulated by Lenin.

11 Loosely modeled on the spectrum of angel, venture, private equity, and hedge fund vehicles collectively known as "alternative investment" asset class in the United States and Europe.

12 Under the 11th and 12th FYPs, Chongqing in western China has been added to this line-up of "beneficiary cities" but based on a different model. Under the national government's planning process, Chongqing is serving as the anchor for China's "Go West" policy as well as the linchpin for new strategic land-routes for importation of minerals and other raw materials from Burma, Pakistan, and Afghanistan.

13 Richard McGregor, *The Party: The Secret World of China's Communist Rulers* (New York: Harper, 2010), 72.

14 See "Eco-Cities in China: Fertile or Fallow," *U.S.-China Clean Energy Blog*, March 3, 2011,www.mterrycooke.wordpress.com/2011/03/03/eco-cities-in-china-fertile-or-fallow/.

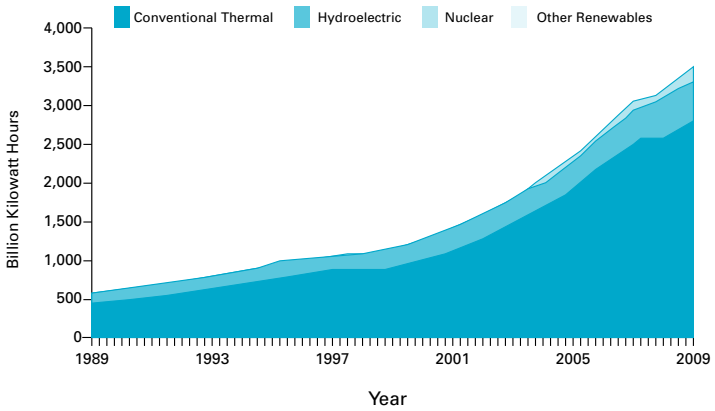
TECHNOLOGY

OVERVIEW

In this chapter, we will be taking a look at the various technology sectors central to U.S.-China cooperation in clean energy. For the most part, this involves surveying the key renewable energy sectors (wind, solar, hydro, biomass), examining a controversial but important non-carbon energy source (nuclear), and looking at certain clean energy initiatives (building energy efficiency, smart grids, and electric vehicles) which are central to the U.S.-China cooperative effort.

Before turning to examine these renewable sectors and initiatives, it is worthwhile to pause and put the discussion into perspective, and that is to place them within the overall scale of the "fossil fuel economy." Depending on whose definition you use, the clean energy economy can refer either exclusively to the renewable sector or can also include the nuclear sector, in which case it is also known as the "alternative energy" economy. However you define it, one glance at the "fossil fuel economy" helps establish a picture of exactly what the clean energy economy is an alternative to. In the chart below, the dark blue area represents China's fossil fuel economy,

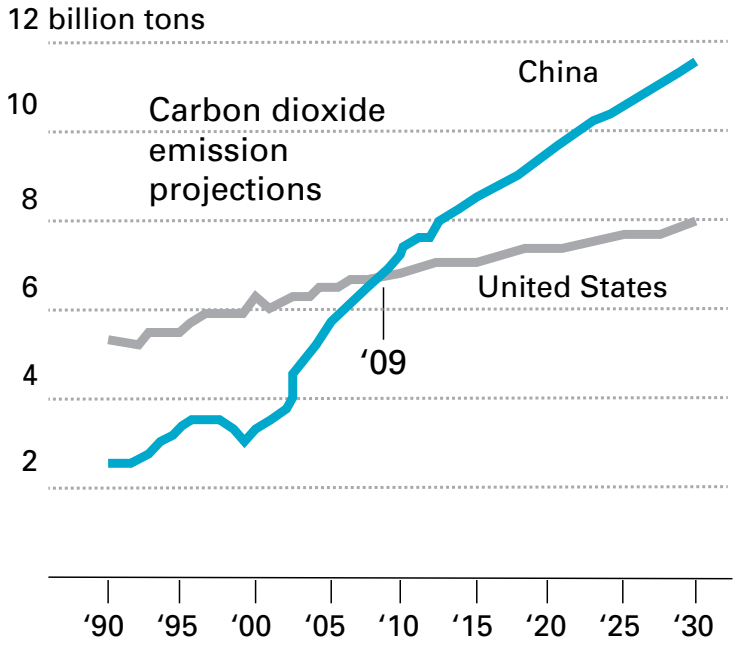
China's Electrical Generation by Type, 1989-2009



Source: EIA International Energy Statistics

the dark intermediate blue area its hydroelectric economy, the lighter intermediate blue area its nuclear economy, and the pale blue area representing the "other renewables" sector of wind, solar, and biomass is simply too miniscule to be visible on the graph.

As the chart plainly depicts, the overwhelming preponderance of China's energy needs are met by fossil fuels. When this fact is then related to the trajectories of the world's two largest carbon dioxide emitters, it is clear that China's past and present reliance on fossil fuels is not comfortably sustainable, either for China or the world.



Source: International Energy Agency

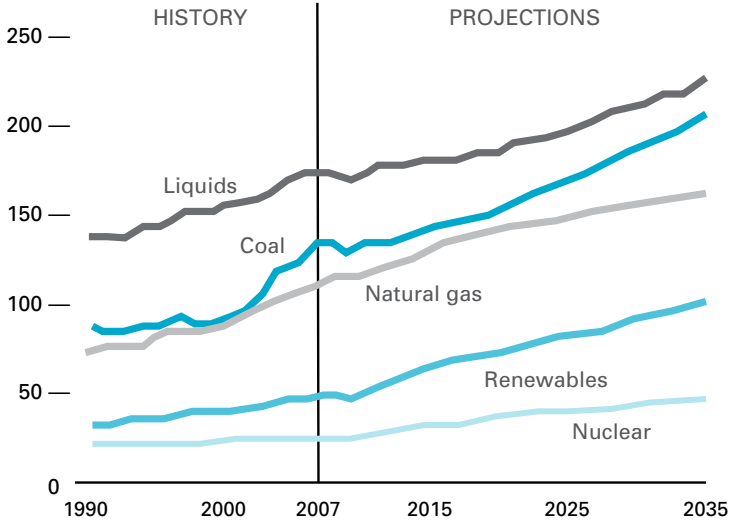
OIL, GAS & COAL: THE "FOSSIL FUELS"

Fossil fuels are the main culprit in the entwined narrative of environmental pollution and global warming for two reasons: (1) their prevalence as an energy source, and (2) the chemistry and "system effect" of how they release carbon-dioxide in the process of producing energy.

Carbon dioxide is not the only greenhouse gas (GHG) which contributes to global warming. Methane, nitrous oxide, and other GHGs can contribute even more steeply on a ton-by-ton basis. But the scale at which the world burns fossil fuels means that carbon-based emissions are overwhelmingly the greatest single contributor to global warming.

This is readily seen by a simple chart from the U.S. Energy Information Administration which shows historical and projected levels of world energy use in five basic categories—liquids (e.g., oil), coal, natural gas, renewables (e.g., wind, solar, hydro, and biomass), and nuclear. We will fine-tune our appreciation for how the United States and China respectively consume energy as we go through the chapter but this chart is as good of a place to begin as any.

World Marketed Energy Use by Fuel Type, 1990-2035 (quadrillion Btu)



Worldwide, the most rapid expansion is taking place in the use of oil and coal. Against this general backdrop, we can now delve into a comparison of the energy consumption and carbon emissions in China and the United States.

As we saw in the chart above, China—with the world's largest population and its fastest growing economy—at the moment contributes roughly one-fifth of global carbon emissions. The United States, with the world's largest economy, third largest population, and a high per-capita income accustomed to a carbon-intensive standard of living, also contributes roughly one-fifth of the world's emissions of carbon-dioxide. While the U.S. aggregate share has been stabilizing, China, in a rapid growth stage, has been increasing its proportion of emissions and, in 2009, China overtook the United States as the world's largest emitter.[1]

The fact that China has recently "overtaken" the United States in emissions mirrors a more general trend of emerging (non-OECD) markets now rapidly outpacing the advanced (OECD) markets in overall energy consumption, an inflection point first reached a few years earlier in 2007. Over this recent period, China has shown progress in its carbon reduction efforts, although this is not readily apparent at the aggregate level and shows up only as a lowering of the "intensity" of per capita contributions. Given the low level of per-capita emission in China and the high rate of growth of its economy, progress at the per-capita "intensity" level will likely continue to be obscured by aggregate expansion of Chinese consumption for most outside observers.

In addition to their release of carbon dioxide into the atmosphere (and the "indirect" follow-on effects of global warming), the three carbon-based fuel sources of oil, coal, and natural gas also tend to leave behind direct environmental fall-out in the form of residues of fossil-fuel burning on land, in bodies of water, and in respiratory systems. Their extraction may also carry serious environmental and human cost.

Oil

While both the United States and China are major producers of oil, both are now deeply dependent on net oil imports. At the moment, the United States is twice as dependent on imported oil as China, with 39 percent of the U.S. primary energy mix imported, in comparison with 19 percent in China, though this relative positioning is changing fast.

For the United States, oil-dependency has been a near-constant feature of the economy since it was first highlighted by the 1973 oil shock. China on the other hand, was originally self-sufficient in oil, becoming dependent on imports only as a result of its extraordinary recent growth. From the 1950s on, China was able to meet its oil requirement from domestic sources, relying in the post-reform period on its three state-owned oil companies: PetroChina, Sinopec, and China National Offshore Oil Corporation (CNOOC). Following Deng Xiaoping's Southern Tour speech in 1992, which launched the second phase of China's economic expansion, domestic oil supplies were no longer adequate to meet domestic demand. Since 1993, the first year in which China became a net oil importer, both oil consumption and oil imports have grown steadily, as could be expected for an economy expanding on average at an annual GDP rate of almost 10 percent.

China's transportation sector, (revved up by an expanding market for privately-owned cars), and its industrial sector, (on which the country's "export-machine" and party leadership directly depend), are the major oil consumers. Absent an economic setback and barring a major overhaul in its subsidized price structure, China's growth in oil consumption should continue to maintain or exceed its current 7.5 percentage rate. With a relatively small base of proven national reserves relative to its high rate of domestic consumption, the share of imports within China's total oil consumption is expected to grow. Over the past five years, the share of imported oil has bounced between the 33 and 50 percentage range. In the near future, China's imports are likely to exceed the share of domestically produced oil. In the longer term, China's planners will try to wean transportation and industrial

users off this source and find domestic replacements. But, as China's thirst for oil continues to grow, and as the share of imported oil in its consumption mix continues to rise,[2] strategic interests in the Middle East become more important to China as does the maintenance of secure maritime shipping routes to supply that oil. This will tend to raise geopolitical stakes[3] for China to a level beyond even the global climate change chessboard.

Gas

Gas represents a lower-carbon substitute for many applications of petroleum. In the United States, natural gas supplies roughly 23 percent of electricity consumed domestically. In contrast, the Chinese figure is in the low single digits because many of the gas deposits are located in the southwest and other remote regions of the country and the gas there tend to be of lower quality than the standard in global markets. Nevertheless, exploitation of gas in China is a priority of planners because there is an untapped domestic supply and it is less carbon-intensive than coal. As a result, natural gas in recent years has maintained a double-digit growth curve in China.

Both countries have promising fields of shale gas, but shale still represents a relatively unconventional source of gas supply.[4] This area is the focus of a bilateral cooperative effort called the "Shale Gas Initiative"[5] under the auspices of the U.S.-China Renewable Energy Partnership.

While oil and natural gas are critical to transportation and industrial power applications, they contribute minimally to electrical power generation. That is the application, in both the United States and China, where coal is king.

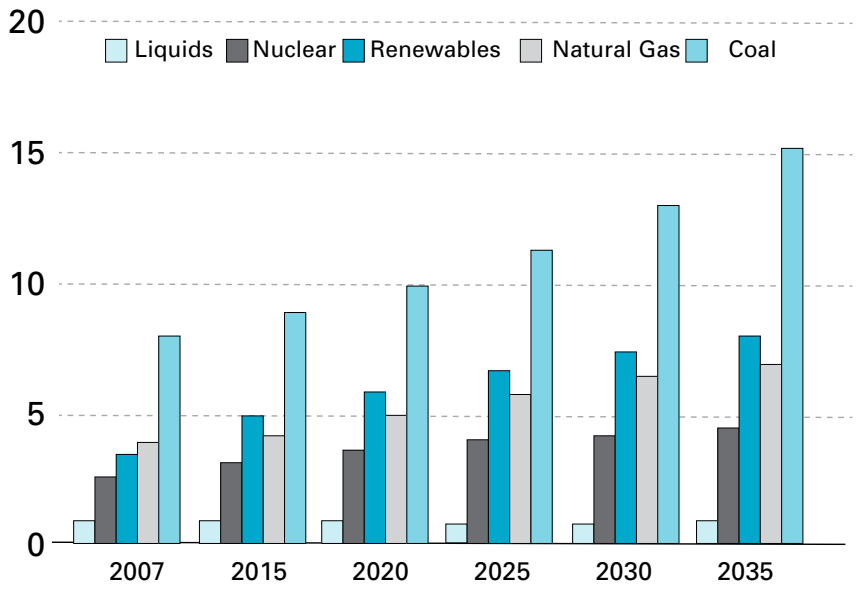
Coal

Among fossil fuels, coal is particularly problematic for the environment. It has a higher carbon-to-hydrogen ratio than oil, natural gas, or other hydrocarbons. This also means that more carbon is potentially available for release into the environment as a result of the breakdown of the hydrocarbon in the energy conversion process.

But chemistry is not the only issue at play. The other issue is prevalence. Coal currently supplies almost half of the electric power generated in the

United States. In China, coal supplies more than 70 percent of electric power generation. These "facts on the ground" are not likely to change soon. In the absence of a comprehensive framework agreement that correctly "prices in" the social costs of coal use,[6] it will continue to be the most readily available, cheapest to exploit, and commercially most sought-after fuel source. Furthermore, the top four coal-reserve countries are the United States, China, Russia, and India—together accounting for 40 percent of the world's population, 60 percent of the world's coal reserves, and 60 percent of the votes in the UN Security Council. Coal is indeed king, which can be readily seen in the graph below.

World net electricity generation by fuel, 2006-2030 (trillion kilowatthours)



Carbon Capture & Sequestration

In December 2010, *The Atlantic* published an insightful article by James Fallows titled "Why the Future of Clean Energy Is Dirty Coal." The title distills the simple but—for Americans—elusive point, captured by the article in an interview with Julio Friedmann, a scientist at Lawrence Livermore National Laboratory:

> *It is very hard to go around the world and think you can make any difference in carbon-loading the atmosphere without some plan for how people can continue to use coal. It is by far the most prevalent and efficient way to generate electricity. People are going to use it. There is no story of climate progress without a story for coal. In particular, U.S.-China progress on coal.*

What makes Fallows' treatment of this story so compelling is that he grounds the topic, for all its abstract "geekiness," in the lives of particular people and in the on-the-ground experiences of specific places.

In the sections which follow, we will be encountering a number of the basic facts which Fallows' article drives home. One is that all renewable energy sources combined currently appear almost negligible when compared to the scale of fossil fuel power generation and, in particular, to the importance of coal in power generation. Second, China is an extreme case in terms of its degree of reliance on coal. Third, while there is no chance that China will back off coal production over the near term, given its favorable economics, there is a likelihood that China will emerge as the world's leader in advanced technologies to "capture" the carbon released in the power generation combustion process and to "sequestrate" it away deep in the earth or in locations where it cannot get into the atmosphere and contribute to global warming. The exotic and expensive technologies which make it possible for coal-burning plants to capture and sequestrate their carbon emissions are called Carbon Capture and Sequestration (CCS).

Ken Lieberthal and Kelly Sims Gallagher blazed the trail for Fallows with a highly-focused "roadmap" publication in 2009 called *Key Opportunities for U.S.-China Cooperation on Coal and CCS*. But it is Fallows who, with a journalist's eye, has drawn out the implications of this technology for future U.S.-China clean energy for anyone to understand.

> *In the search for "progress on coal," like other forms of energy research and development, China is now the Google, the Intel, the General Motors and Ford of their heyday—the place where the doing occurs, and thus the learning by doing as well. "They are doing so much so fast that their learning curve is at an inflection that simply could not be matched in the United States," David Mohler of Duke Energy told me.*
>
> *"In America, it takes a decade to get a permit for a plant," a U.S. government official who works in China said. "Here, they build the whole thing in 21 months. To me, it's all about accelerating our way to the right technologies, which will be much slower without the Chinese.*
>
> *"You can think of China as a huge laboratory for deploying technology," the official added. "The energy demand is going like this"—his hand mimicked an airplane taking off—"and they need to build new capacity all the time. They can go from concept to deployment in half the time we can, sometimes a third. We have some advanced ideas. They have the capability to deploy it very quickly. That is where the partnership works."*

American ideas and Chinese deployment. This is how clean energy breakthroughs can happen fast and it is how they can be brought to global scale. This is where U.S.-China clean energy cooperation can show practical impact in addressing the global climate change challenge.

We will be returning to this model of U.S.-China partnership in the Observations and Conclusion Chapter.

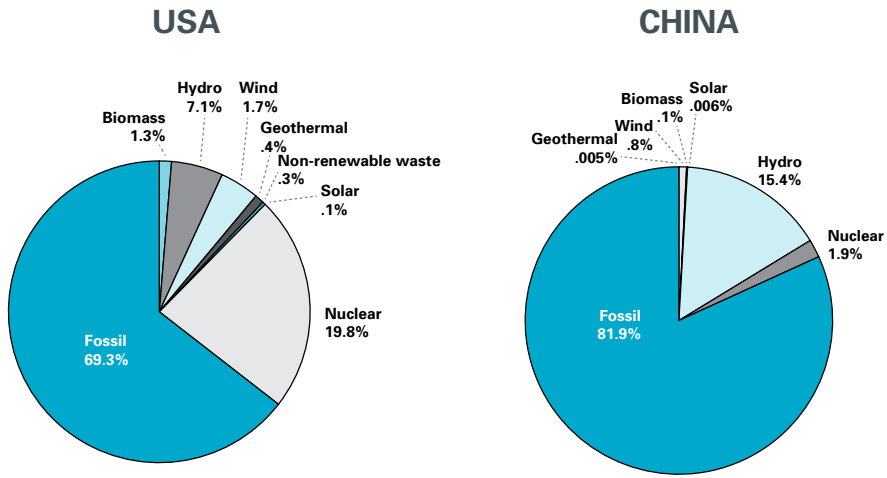
Wind, Solar, Hydro & Biomass: The "Renewables"

To lead in to our discussion of the individual renewable energy sectors and several noteworthy sectoral initiatives, it will be useful to begin with a com-

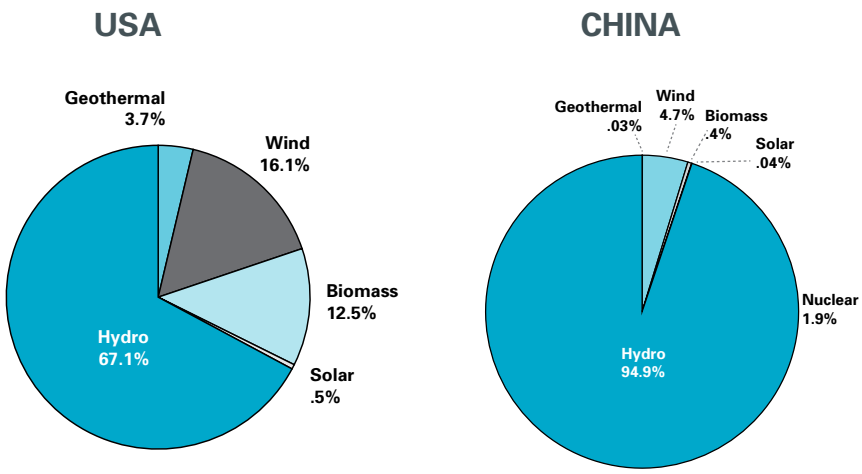
parative look at (1) the breakdown of sources on which the United States and China rely to generate their electricity; and (2) a chart showing which renewable energy sectors are showing the fastest growth in each country.

1. STRUCTURE OF ELECTRICITY GENERATION

Structure of Electricity Production - 2009

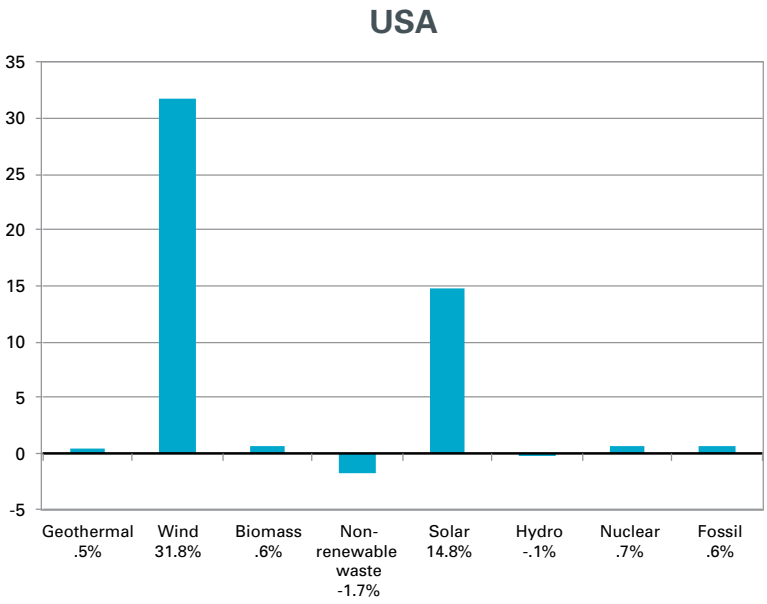


Structure of Electricity Production from Renewable Source - 2009

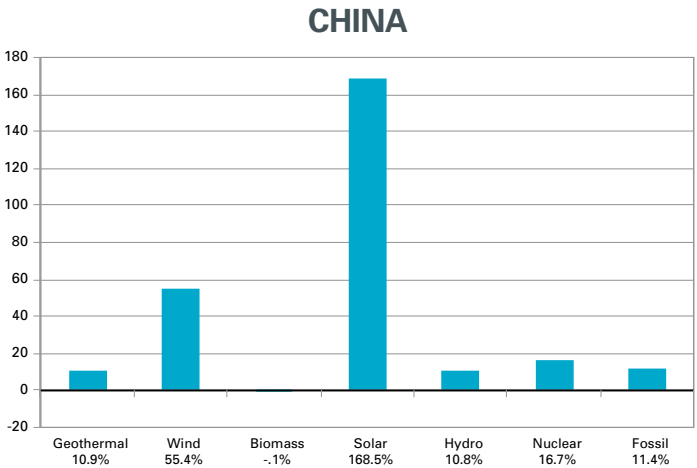


2. AVERAGE ANNUAL GROWTH RATES BY RENEWABLE ENERGY SECTOR

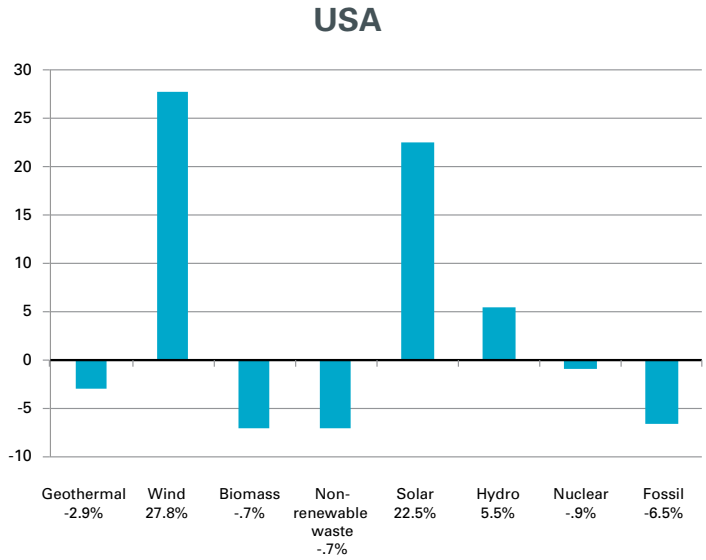
Average Annual Growth Rate 1999-2009

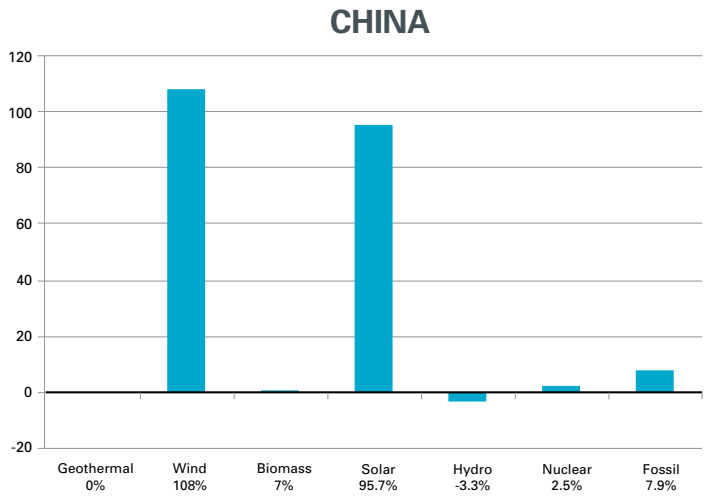


Average Annual Growth Rate 1999-2009



Growth Rate 2008-2009





The sharp contrasts which these charts throw into relief are:

- China's current overwhelming dependence on fossil fuel and hydropower for its overall power generation needs as contrasted with a more balanced profile in the United States (with greater contribution by nuclear and renewable sources and much less dependence on coal);
- With the renewable portion of its electricity generation, China has an overwhelming preponderance of contribution by hydropower and currently, only a small contribution by wind. In the United States hydropower claims a smaller share but there is a robust and diversified contribution by wind, biomass, and geothermal;
- In neither country does solar yet contribute much. But, in the United States, the solar contribution is at least "visible" in the graphic whereas it is entirely "invisible" in the Chinese graphic;
- As for average growth rates in the renewable energy sector, both the United States and China are showing strong growth in wind and solar. The most notable difference here is that China's growth rates, against a smaller established base, are generally four- to six-times the growth rates seen in the United States.

Wind

The story of the United States and China in wind energy has dramatic elements—a deep back story with some intrigue, strong support for each industry in its respective home-market, and an increasingly vigorous contest for international position. Attempts at cooperation on this landscape are visible but they remain relatively few and fragile and competitive tensions are more rampant.

First, let us look at the technology. Although relatively sophisticated windmills based on vertical axis design have been around for more than a millennium,[7] the modern version—involving massive turbines generating and feeding electricity directly into utility grids—is thoroughly modern. Spinning off from the modern aerospace industry, wind turbines represent

a remarkable feat of systems integration at the design level and of exquisite sophistication at the manufacturing, shipping, installation, and operational levels. Pioneered in 1979 by Danish manufacturers, serial production of wind turbines started in Europe, and then spread quickly to North America in the mid-1980s, particularly to California. China has been a late entrant in the industry, with its initial wind turbine manufacturing experience coming with the establishment of Goldwind （金风科技股份有限公司） in Xinjiang Province in 1998.

Through the first decade of the 21st century, this national "birth-order" of wind technology adopters correlated with global market position. For instance, as measured by the percentage contribution which wind power contributed to each company's domestic energy market in 2009, wind power contributed 20 percent in Denmark, 14 percent in Spain, 2 percent in the United States, and less than 1 percent in China. Powering each of these country markets was a national champion turbine manufacturer: Vestas from Denmark; Gamesa from Spain, and GE from the United States. Siemens, Alstrom, and a handful of other companies have more recently joined the ranks of these three in global markets.

China, as a result of its late start, did not enter the 21st century with either a strong installed base of wind-generated power contributing to its electrical grid, or in a competitive posture to supply global markets. What changed?

In 2000, as China's central government began its push to develop clean energy, Gamesa became the early market leader in China's wind generation market. With labor costs lower in Spain than for its Danish and U.S. competitors, Gamesa was able to appeal to price-conscious Chinese government buyers and by 2005, had secured nearly a 35 percent share of all installed wind-power capacity in China.

But even as Gamesa was building this market share, it became clear that the procurement contracts it was winning called for increasing amounts of components to be supplied by local Chinese suppliers instead of from Gamesa's established network of overseas suppliers.

What began as a noticeable trend then became announced state policy when, on July 4, 2005, the National Development and Reform Commission proclaimed Notice 1204, which stipulated that only wind installations with at least 70 percent of total value procured from locally manufactured components would henceforth be allowed in China.

This type of local content requirement is patently proscribed by WTO rules for free and open trade, the very rules which China had promised to adhere to in exchange for the country's WTO accession in 2001. But it takes time to mount a WTO challenge and, in the meantime, a major supplier in a fast-growing Chinese market segment rarely wants to risk its established position by bucking the system. Accordingly, Gamesa initiated local procurement training programs to teach domestic suppliers in China to manufacture to its exacting quality specifications. In 2005 the Chinese market for wind turbine installations started growing exponentially, propelled by ambitious government plans and ramped up spending. By 2010, Vestas had eked out a doubling of its turbine installations over the 2005 level but, due to the dramatic expansion of the Chinese wind-power market over this period, the company saw its market share drop from nearly 35 percent to only 3 percent. More galling, Vestas now faced a crowd of brand new Chinese competitors, many of whose executives Vestas had been effectively coerced to train in their supplier program. With the advantage of lower labor costs and government financial backing, these Chinese competitors were crowding Vestas out of the Chinese market and eyeing foreign markets where Gamesa's higher cost structure made it vulnerable to new entrants from China.

It was not until 2009, after the collapse of the Copenhagen round, that the Obama administration began taking seriously the concerns raised by GE and others over China's localization practices in the wind sector. Closer examination showed that Gamesa's experience was not unique. Goldman Sachs research indicated that, over the same 2005-2010 period, the overall share of foreign suppliers to China's domestic market had fallen from 79 percent to 13 percent.

In September 2009, the United Steelworkers (USW) presented an omnibus complaint against Chinese unfair trade practices in renewable energy to the U.S. Trade Representative's Office. The administration chose in December to take up officially only the wind-power component of that complaint, a formal WTO dispute action which the Chinese eventually proposed to settle in mid-2011. By that point, however, the horse was already out of the barn.

The cumulative effect of these changes in the China market was now becoming visible in the global race for market leadership. In 2008 China could be seen rapidly closing the gap with the traditional market leaders—the United States, Germany, and Spain. By 2009, China, riding a massive post-GFC stimulus program, became the world's largest buyer of wind turbine equipment. In that same year, the United States managed to maintain its strong pace of wind installations but Spain and Germany started falling off the global pace as post-GFC austerity forced them to drop governmental price supports (so-called "feed-in-tariffs" or FITs) for wind installations. Finally, in 2010 China surpassed the United States in wind-power installations (18.9 GW vs. 5.6 GW) and emerged as the clear global front-runner for wind-energy purchases and installations. The chart below makes clear the speed of China's rise in this field.

Position 2010	Country/ Region	Total capacity end 2010 (MW)	Added capacity 2010 (MW)	Growth rate 2010 (%)	Position 2009	Total capacity end 2009 (MW)	Total capacity end 2008 (MW)	Total capacity end 2007 (MW)	Total capacity end 2006 (MW)
1	China	44,733	18,928	73.3	2	25,810	12,210	5,912	2,599
2	USA	40,180	5,600	15.9	1	35,159	25,237	16,823	11,575
3	Germany	27,215	1,551	6.0	3	25,777	23,897	22,247	20,622
4	Spain	20,676	1,527	8.0	4	19,149	16,689	15,145	11,630

In a mid-summer 2011 settlement announced by the Office of the U.S. Trade Representative, the Chinese government agreed to stop subsidizing its wind-power manufacturers. However, the value of this victory for the United States' WTO case has more to do with political symbolism than rolling back the facts on the ground. In the post-GFC environment, China's government has the financial ability to support the expansion of its industry by other means, such as through its "Chinese companies going global" campaign. With a firm hold over 70 percent of the largest and fastest-growing wind-energy market in the world back at home, Chinese wind-energy giants Sinovel (11.7 percent global share as of 2011[8]), Goldwind (9.5 percent), DongFang (6.7 percent) and United Power/State Grid (4.2 percent) all have strong backing as they begin their attempts to crack the U.S. market.

For the moment, there is still a huge asymmetry in the number of installations which GE has made in the Chinese market (over 1,000 in China alone and over 14,000 worldwide) versus the number of installations Chinese wind-power companies have made in the U.S. market (three installations, as of December 2010). Moreover, lingering tight credit strongly favors established market leaders when it comes to wind-energy projects and, for now at least, financing costs remain currently prohibitive for new entrants. Nonetheless, no one tracking the U.S. market expects the Chinese turbine-makers to be locked out of the market for long. Major financial institutions are recommending the Chinese turbine makers as a recommended buy with long-term upside. Goldwind is pursuing a patient strategy of building up a U.S.-based operation, employing a U.S. workforce, and establishing a reputation for quality. It is a conscious and attention-worthy effort to take a page from the playbook Toyota successfully used to break into the U.S. market in the early 1990s.

Even market-leader GE seems to be hedging its bets as far as Chinese turbine-makers are concerned. With an eye on the 500 percent increase in wind capacity expected for the Chinese market by 2020, GE entered into a major cooperative joint venture with Harbin Electrical Machinery

Company in September 2010. Undaunted by the Vestas experience and cognizant that "no international wind turbine generator company has won a major Chinese national tender…since 2005,"[9] GE's joint venture gives a local face to the manufacture, supply, and servicing of GE turbines for China's onshore and offshore wind markets.

Solar

Interestingly, the market picture for the photovoltaic (PV) solar industry in China is almost the reverse image of what we have just seen for wind energy. With wind energy, China has a domestic market to fall back on if it is rebuffed in its market entry into the United States. With solar, China is entirely dependent on continued access to Western export markets because China has not yet, to date, established any domestic market for its solar production.

To start from a broad perspective, it should be noted that the solar industry worldwide is divided into two major sectors. The largest and most commonly thought of sector is photovoltaic solar. This technology employs "micro-chips" on solar panels that manage the direct photovoltaic conversion from sunlight to transmission-ready electricity. Photovoltaic is the technology commonly seen on the rooftops of private homes as well as in utility-scale arrays in "solar-farm" fields. The second sector of solar technology which offers comparable long-term promise as a source for renewable energy is thermal solar. In contrast to PV, thermal solar technology uses the direct energy of sunlight for various heating and/or electricity conversion processes. These can range from simple solar-heating units on rooftops to heat the water for building occupants to extraordinarily complex and precise arrays of mirrors that can redirect tens of thousands of beams of light to superheat synthetic fluids which in turn boil water to power steam-turbines for large-scale electricity conversion.

We will be focusing mostly in this section on dynamics in the global photovoltaic industry. But before leaving the topic of solar thermal, we should note in passing that China is already the world's largest market for installa-

tions of simple and inexpensive solar-heating rooftop units. Under cloudy conditions, these units do not always provide occupants the most satisfying temperature for their hot showers but they conserve a significant amount of energy that would otherwise have to be generated by coal or other carbon-based sources. At the other end of the spectrum of sophisticated thermal technologies are the vast arrays currently under experimentation in some of the world's biggest deserts. The grandest of these experiments, Desertec, is currently under construction in North Africa as a German-led, EU- and World Bank-backed effort that could potentially supply Europe, via a trans-Mediterranean high-voltage transmission line, with 15 percent of its energy needs. A step down in scale from Desertec is California start-up eSolar, which is backed by US $40 million of funding from GE, and has a licensing deal with Chinese power equipment maker Penglai Electric to build 2GW of solar thermal projects in Shaanxi Province and other locations over the next 10 years. Solar thermal power is promising but still at an early stage of development.

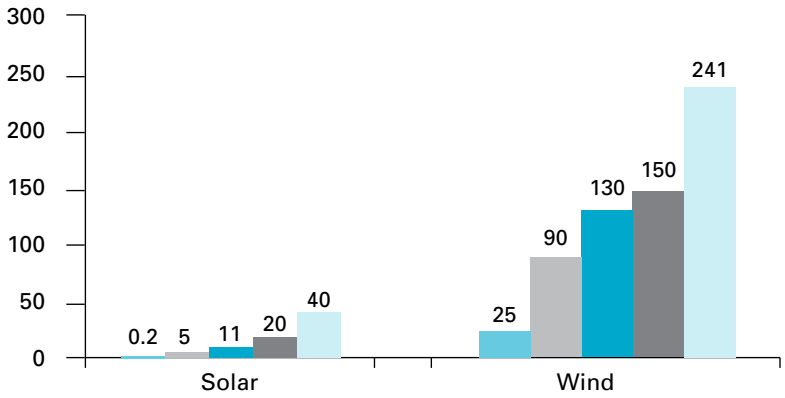
PV solar is where the strongest global competition is currently taking place with China in the thick of the action. This is, in fact, a boom industry in China. As an investment sector, it enjoys relatively low barriers of entry compared to other high technology fields, can take full advantage of China's relatively low labor and facility costs, and can piggy-back on the global primacy Asia has established in the related manufacturing field of low-cost memory chips for the computer industry.

To illustrate this point, a single city in Shandong province, Dezhou, alone is home to more than 100 PV manufacturers. The recent high profile issue of tight polysilicon supply in global markets shows clearly the government support backing this industry sector in China. In late 2010, when this critical supply input for the industry dried up in global markets, the full state apparatus of the PRC central government went into gear to assure supply for the sector, a story well described by the *Wall Street Journal* in November 2010.[10] With supply being ramped up by "investor euphoria" factors and with domestic demand limited by the State Grid's ability to integrate new

PV-generated power into its national grid, prices in China started dropping precipitously. But with state support for the industry evident in unclogging the polysilicon bottleneck, Chinese solar producers took heart. The plight for the plethora of start-ups in China was no longer an existential question of "Will I survive" but now a more zero-sum question of "How much market share can I grab under current conditions."[11] As reported by *RenewableEnergyWorld.com* in September 2010, "the late-August round of bids for utility-scale solar power projects in China yielded a new milestone in the economics of solar power in China: a sub-yuan/kilowatt hour (kWh) price for solar power. To achieve this impressive number, the Chinese government has used the state-owned sector (and particularly enterprises under the direct control of the central government) to help subsidize the price of solar power, to the point where the economics appear to be unsustainable."

What makes this "Chinese story" problematic in a global sense is that, unlike the wind sector, China has, relatively speaking, no established domestic market for PV solar production. This is readily shown by a graphic representing the size and growth prospects of the PV solar market in comparison with the wind energy market.

Clean Energy Forecasts: Installed Capacity
Government of China Targets vs. HSBC Estimates (GW)



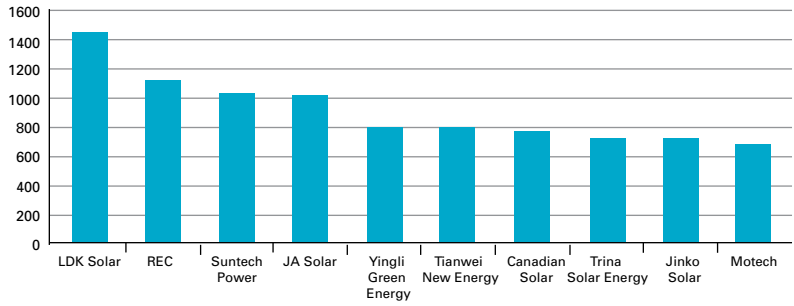
Note: GoC is Government of China

Source: HSBC, China Business News

What this means is that the output of China's recent hyper-production needs to be absorbed in export markets. Because cost-of-production is less important to Chinese manufacturers than sales volume, the oversupply situation in China leads to falling prices in international markets.

By the end of 2010, this situation had already yielded a 30 percent global share for China and a growing international backlash as profit & loss (P&L)-driven companies in the United States and other export markets[12] succumbed to this wave of imports from China. The global ranking of PV manufacturing expansion in 2010 tells the story clearly with Chinese companies occupying seven of the ten ranked slots.

Top 10 Ranked Companies Conducting PV Cell and Module Manufacturing Expansions in 2010, in MW (estimated for entire year 2010)



Source: iSuppli

Rank	Company Name	Headquarters	Cell & module expansion (MW)
1	LDK Solar	China	1420
2	REC	Norway	1090
3	Suntech Power	China	1025
4	JA Solar	China	1000
5	Yingli Green Energy	China	800
6	Tianwei New Energy	China	800
7	Canadian Solar	Canada	760
8	Trina Solar Energy	China	700
9	Jinko Solar	China	700
10	Motech	Tiawan	680

As a result, the Obama administration is under increasing pressure in 2011 to broaden its trade actions against China in the renewable energy category to include PV solar products.

However, despite these pressures, the U.S. industry is demonstrating remarkable innovativeness and resilience at the higher value end of the market. The U.S. government has funded a new national Energy Innovation Hub for Solar Technology led by CalTech. There is currently no major bilateral effort on-going between the United States and China in the PV solar area, either at the level of U.S-China Clean Energy Research Center (CERC) cooperation or non-official public/private partnership channels.

At the private sector level, some high-profile efforts have managed to withstand these whipsaw pressures and to find common ground with China. The most notable of these is the plan by First Solar, Inc., headquartered in Arizona, to cooperate with China Guangdong Nuclear Solar Energy Development Co., Ltd. to develop the world's largest solar power plant in Ordos, Inner Mongolia. The memorandum of understanding for this project, signed in January 2011, envisions a 2,000-megawatt solar power plant for thin-film transistor (TFT) solar PV modules to be built in phases over the next 10 years.

Hydro

The hydro power story, while interesting for what it illuminates about the historical ambitions of ruling elites in both countries, sheds little light on either the cooperative or competitive dynamics between the two countries. Some opportunities for technology exchange exist—such as intra-riverine turbine installations to convert the force of flowing river water into electricity. Generally speaking, however, hydro power in both countries has developed on a self-sufficient basis with little inducement for international involvement.

Hydro power, the set of technologies used to generate energy from the movement of water, has a centuries-old connection to rivers, converting the energy latent in water as it moves down altitude gradients from its source to sea-level. Despite this long pedigree, hydropower is sometimes

viewed as suspect within the family of renewable energy sources due to its identification with well-recognized negative impacts—environmental (erosion, ecological disequilibrium, etc.), social/cultural (e.g., large-scale relocations) and even economic (as silting and earthquake risks impair returns on investment).

While hydro power is generally peripheral to U.S.-China dynamics of cooperation and competition, it deserves a measure of attention for our purposes. In the first place, it is the renewable energy source with the longest history of deployment at substantial scale in both countries. Further, it accounts for the largest share of power generation capacity among the renewable energy family in both China and the United States, with both ranking as world leaders in hydroelectric-generating capacity.

A second reason for attention has to do with what hydro power reveals about a country's self-image. In the 1930s, Woody Guthrie eulogized the Grand Coulee Dam as "the grandest dam(n) thing ever built by a man." Similarly, China has had a long-standing preoccupation with massive waterworks.

The world's largest current installation at the Three Gorges Dam, spanning the Yangtze River in Hubei Province, was originally envisioned as early as 1919 by Sun Yat-sen in *The International Development of China*. Instability in China during the Japanese Occupation and subsequent Civil War between the Chinese Communist Party and the Kuomintang, interfered with the realization of these plans but, following the Communist victory in 1949, they were belatedly revived. Hydroelectric installations became a symbol of socialist self-sufficiency and were pursued aggressively. The high-water mark, figuratively and literally, of China's boom in large-scale dam construction occurred with the construction of the 22.5 GW Three Gorges Dam, finally completed in October 2008.

Another engineering mega-project which has drawn its share of controversy is the multi-decade "South-North Water Transfer Project," diverting water from the central Yangtze River to the northern Yellow and Hai rivers. While the Three Gorges Dam project was intended to generate power and

control flooding, this massive project aims at addressing water shortages and rebalancing supply between the north and south. Each project has generated controversy over cost effectiveness, environmental and social impacts, and security concerns.

The legacy of this long involvement with hydroelectric power generation is significant. As of today, hydroelectric power contributes more than 20 percent of China's total installed power generation capacity from all sources including traditional coal, cleaner renewable sources, and more scalable nuclear power sources. In aggregate, hydro contributes over 600 billion kWh to China's power generation, more than five times the current aggregate contribution of all other renewables (wind, solar, and biomass) *plus* nuclear generation. As a yardstick by which to measure hydroelectric's installed contribution relative to other renewable and low-carbon sources, hydroelectric power generation in China in 2010 is outstripping wind by an eight-fold factor, nuclear by a 20-fold factor, and solar by more than a 1,000-fold factor.

This is not to suggest that China's hydro potential is tapped out. To the contrary, installed capacity in 2006 was 117 million kilowatt (kW), representing only about one-quarter of the country's full hydro potential and, in recent years, the technology is undergoing something of a rebirth in China. Given the ambitious official target which China has set for at least 15 percent of total power to be generated from renewable sources by 2020, hydro is now being asked to contribute its share of this target. In October 2010, the government pledged to boost hydro capacity by 50 percent by 2015. Similarly, longer-range plans call for approximately 300 million kW to be generated from hydro sources in 2020, almost a doubling from the 2006 level. Two large-scale facilities on the upper reaches of the Yangtze at Jinshajiang have already been launched and more than a dozen projects, mostly in western China, have been identified and evaluated. According to a senior energy journalist and sources within the Beijing-based Global Environmental Institute, these new projects will "account for 67 percent of the nation's total economically exploitable water resource."

Notwithstanding these and other instances, we should not expect international collaborations to be at the forefront of this next wave of hydropower expansion in China. The PRC has impressive experience in large-scale infrastructure projects dating back decades and, as China's economic reforms have accelerated, major projects skills have been increasingly honed in Africa, the Middle East and other international markets. In short, China's hydropower workforce has world-class competence in the areas of design, construction, and equipment manufacturing. Their need for foreign assistance in these areas is limited. As an international expert has noted, "There is no technology barrier. China is capable of independently undertaking hydro projects of any technology or scale."

While opportunities for business cooperation are limited in the larger scale projects, there are two areas where prospects are brighter: (1) the contribution of distributed systems of "small hydro;" and (2) overcoming the technical challenges involved in the "interconnect" between the areas where most hydropower is generated (overwhelmingly in the high-altitude southwestern and western portions of the country) and the locations where the power is consumed (overwhelmingly along the developed eastern seaboard of the country).

In a larger sense, water resources are likely to prove critical to a global warming scenario which China might expect. As Elizabeth Economy noted in her 2009 testimony to the Senate Committee of Foreign Relations, China faces serious, water-related challenges if global climate is not stabilized. These include inundation along the coastline and riverine systems and an even greater degree of desertification (a condition which already afflicts 20 percent of the country).

Biomass

Biomass refers to a renewable energy source which converts organic feedstocks, usually plant matter, into biofuels for the purpose of generating electricity, producing heat, or serving as an additive to conventional fuels.

The most common feedstocks for the biomass conversion process are: (1) organic wastes (such as municipal solid waste, wastewater, sludge, and manure); (2) wood, stalk, and grass residues (from forestry or agricultural activities and from urban/suburban activities); and (3) non-food crop plants such as switchgrass, sorghum, algae, and waterweeds. Biomass is converted to biofuel by both "wet" biochemical processes of anaerobic digestion and fermentation and by "dry" thermochemical processes of thermolysis, gasification, pyrolysis, and incineration.

In the United States, investment in biofuels has seen a series of peaks and troughs. These ups and downs have generally tracked regulatory moves to either promote or limit specific forms of biomass commercialization. By far, the most widespread instance has been regulations promoting corn ethanol as an additive for gasoline. From 2000 to 2008, corn ethanol rose from constituting 1 percent of America's fuel supply to fully 7 percent. Backed by a strong ethanol lobby on Capitol Hill and U.S. Environmental Protection Agency (EPA) findings that it emits 20 percent fewer GHGs than regular gasoline, corn ethanol was supported by an extensive subsidy program amounting to tax credits of nearly US $23 billion over the 2005-2010 period. As a result, fully one-third of corn production in the United States is now devoted to ethanol. With ethanol supply approaching its mandated 10 percent limit as a fuel additive, its advocates argue that improvements in the conversion process justify that limit being raised to 25 percent. However, most policymakers seem to be going in a different direction based on recognition that corn ethanol is significantly less efficient than sugar-derived ethanols from Brazil and elsewhere. Reflecting this, last year's Renewable Fuel Standard (RFS) put a limit of just over 40 percent on the share for corn ethanol in the 36 billion gallon mix of renewable fuel mandated for use in the transportation sector by 2022. While a clear domestic competitor to corn ethanol has yet to emerge at commercial scale, the government is increasing its funding for research and development into algae-based biofuels.

In China, the storyline has been less about corn farmer lobbying and

more about drastic spikes in the price of foodstuffs. China, like India, was both an instigator and victim of rising food costs. As economic growth expanded the ranks of its middle class and as tastes and buying habits in these two countries shifted towards calorically less efficient fare such as meat, world prices began to skyrocket for a broad range of food commodities from pork to the grains used to feed livestock. Though this trend diminished with the onset of the Global Financial Crisis, the structural aspect of this cycle, tied to the enrichment of large consumer sectors in the world's emerging economies, was evident. The screw has turned in 2011 and, again, prices for food and a broad range of basic commodities are on a sharp upswing.

The background of rising food costs and the relative scarcity of arable land has led to a distinctive development of the biomass industry in China as compared to the United States. The trend in China is much less rooted in large-scale cultivation (e.g., cornfields in the United States or sugarcane fields in Brazil) and more focused on converting marginal refuse and waste products associated with agriculture, animal husbandry, and forestry into usable forms of energy. These bio-energy sources—the availability of agricultural and forestry waste each approach one billion tons per year—are abundant. However, they are difficult to collect and deliver. Even when collected, this biomass tends to be used in relatively inefficient ways such as feed for cattle, fuel for rural cooking and heating, re-fertilization of soil, or outright incineration in fields.

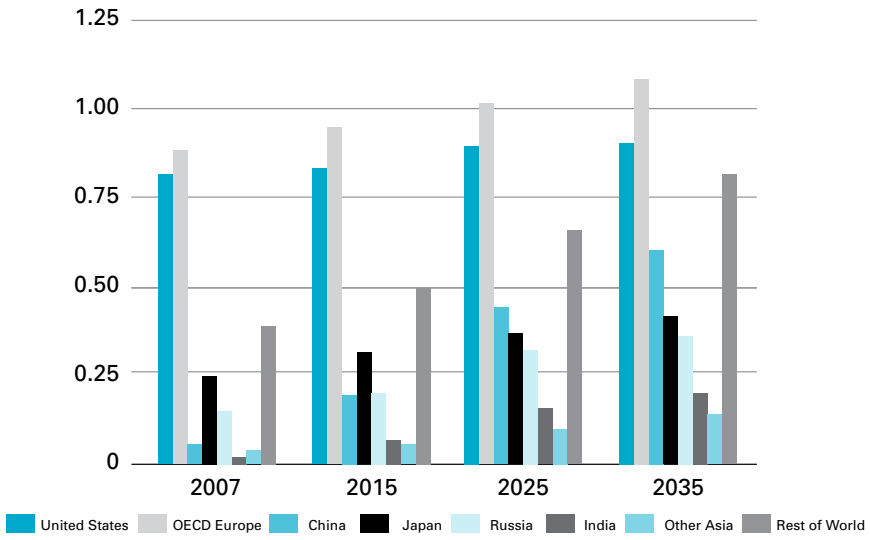
One more efficient use of these refuse and waste products which China has been developing intensively is its use to raise the efficiency of coal power generation. This is achieved in a number of different ways. As of today, more than 100 projects use biomass directly in combustion to produce more than 1800 megawatt electric (MWe) of annual power generation (through a technique known as vibration bed boiler). Other techniques involve pelletizing and/or gasifying biomass so that it can be co-fired with coal to produce electricity. China's biomass is also converted to ethanol and biofuels but at a substantially smaller scale than in the United States.

In both China and the United States, biomass is an important and necessary part of the overall clean energy solution but it will never be more than a relatively small "wedge" of that overall solution. As comparatively quantified and interpreted by David McKay in his excellent study *Sustainable Energy–Without the Hot Air*, "One conclusion is clear: biofuels can't add up—at least, not in countries like Britain, and not as a replacement for all transport fuels. Even leaving aside biofuels' main defects—that their production competes with food, and that the additional inputs required for farming and processing often cancel out most of the delivered energy—biofuels made from plants, in a European country like Britain, can deliver [relatively] little power..."[13]

Nuclear Power

The first commercial nuclear power plant in the United States was installed in 1958. Today 104 commercial reactors produce almost 20 percent of the nation's total electric generation. By comparison the first nuclear plant installed in China, Qinshan Nuclear Power Plant near Shanghai, only became operational in 1991. Today 13 plants are in operation supplying just over 1 percent of China's total electricity generation. This freeze frame comparison of installed nuclear capacity in the United States and China fails to give an accurate sense of today's picture of the relative importance of nuclear industry to the two countries, however. Of the 52 nuclear power plants that were either under construction or in advanced planning in the United States and China as of late 2010, (just months before the tsunami and nuclear breach occurred near Sendai, Japan), 50 of those plants were being planned and built for the Chinese market.

World Net Electricity Generation from Nuclear Power By Region, 2007-2030 (trillion Kilowatthours)



The imbalance in planned construction revealed in the above chart from the U.S. Energy Information Administration clearly shows the contrast between the plateaued market for nuclear in the United States and EU, and the rapidly growing market in China, India, and the rest of the developing world. While active plants in the United States are approaching the end of their licensing lifetime without clear plans for replacement, the number of nuclear installations in China is expected to be expanded by as much as 900 percent over the next nine years.

Following the Three Mile Island incident in 1979, the general U.S. experience for the nuclear industry has been the cancellation of new orders, the postponement or abandonment of new construction, premature shutdown of plants before expiration of their 40–year operating license, or extension without plans for replacement. Although improved design and technology advances have brought about significantly improved safety performance, public opposition to nuclear power—periodically galvanized by highly pub-

licized international incidents such as Chernobyl and Fukushima, and persistently bedeviled by the nuclear waste disposal problem—has kept the U.S. market virtually off-limits to new nuclear installations over the past three decades. China, by contrast, is the world's most active site for new plant installations. National planning calls for nuclear power to provide 6 percent of China's total electrical generation by 2020. This will require a net increase in installed capacity of 60-70 GW, roughly comparable to the entire 63 GW of currently installed nuclear capacity in France, one of the world's most active users. By 2030, China plans to match the nuclear output currently provided by all 104 installations in the United States.

While the U.S. experience has been determined largely by public concerns over safety and waste disposal issues, Chinese market acceptance has been driven more strategically by a governmental elite, many of whom were trained as engineers. Part of their strategic thinking appears to be motivated by the challenges of climate change and of transforming China's industrial structure for electricity generation and moving it decisively toward lower-carbon sources. As the vice president of the China Nuclear Energy Association has pointed out, nuclear power—rather than solar, wind, or biomass—is "the only energy source that can be used on a *mass scale*" to achieve clean, low-carbon energy.

Beyond this, however, plans for the rapid expansion of nuclear power in China also appear designed to upgrade the capabilities of the Chinese nuclear industry by enticing foreign suppliers who want to participate in the market growth in China to share their advanced technology with Chinese partners. Not only is the profit potential vast in China, but other big emerging economies, such as India and Brazil, will be coming on-stream for nuclear installations in the decades ahead as well. To position itself to wrest some of that business away from the established incumbents, such as France's Areva and Japan's Westinghouse, China has some strong advantages at its disposal—low-cost labor and deep experience with major infrastructure projects. This means a Western-designed reactor can be built in China for 40 percent less cost and 36 percent faster than that same installation in Europe.

For China to realize this ambition, its two major nuclear power companies—China National Nuclear Corporation and China Guangdong Nuclear Power Group—will need to break into the more knowledge-intensive parts of the business where they currently have only limited experience. Of the 13 nuclear power plants currently operating in China, only three—all at the original Qinshan site—rely on an indigenously developed design. Likewise, China has only limited experience in selling its reactors in export markets, with Pakistan being the only known foreign buyer to date. Finally, to upgrade its industry to the point that it can compete in global markets with the established players, China will need to develop the ability to manufacture specialized components, for which it is currently dependent on foreign suppliers. These include reactor vessels, steam generators, and large-forge nozzles.

As for U.S.-China strategic cooperation in the nuclear field, there have been important undertakings accomplished on a piecemeal basis but, to date, nothing attempted on a broad and strategic basis by the two governments. There are interesting opportunities on the horizon, though. Former U.S. Ambassador to China, Jon M. Huntsman Jr., has reported discussing with Bill Gates a new kind of reactor "that runs for decades on a single fuel load, making and destroying plutonium as it runs" and thereby reducing the hazards of reprocessing and the dangers of proliferation. According to Ambassador Huntsman, strategic cooperation between the two countries to develop this American-pioneered technology could bring shared benefits. The technology could, for example, be certified and brought to commercial scale in China in a fraction of the time required under the current U.S. regulatory climate. A partnership effort of this sort could be envisioned with a joint American-Chinese company to lead the construction, co-development and commercialization rights apportioned between the two partners, and with the end-result a cleaner and (marginally) safer form of energy being brought quickly and at scale to consumers.

INITIATIVES

Energy Efficient Buildings and "Green Cities"

In both China and the United States, buildings consume roughly 40 percent of all energy. Obviously, a significant reduction in carbon emissions is possible if new buildings are designed to minimize their use of carbon-intensive building materials and are operated in ways that maximize energy efficiency. Similarly, older buildings can be retrofitted using an array of advanced energy-saving components such as window and lighting technologies, "cool roofs," and building "skins." If employees and residents are given easy-to-operate, interactive tools and then educated about optimizing the energy efficiency of their environment, even more substantial energy savings are possible.

In the United States, it is in the second and third of these areas that the greatest impact can be realized. The vast preponderance of both the commercial and residential real estate markets in the United States involve the existing stock of buildings, rather than new construction. Since there are relatively few new buildings entering the U.S. market at any given time—at least in comparison with faster growth, emerging economies like China—the potential impact of energy efficient design for new buildings is relatively modest and requires a longer timeframe. It is for this reason, as we will examine in detail in the next chapter, that the Department of Energy focused its new national energy innovation hub for building energy efficiency on the retrofit of older buildings and on consumer behavior and business modeling.

In China, it is exactly the opposite situation. The central government has for years been involved in a massive program of relocation and resettlement. Each year during the 2006 to 2011 planning period, more than 15 million people have been relocated from China's rural regions and resettled in urban settings. This program has been undertaken in part to allow the consolidation of small rural landholdings into larger scale, more efficient units of agricultural production. But it has also been done for reasons of

energy efficiency, delivery of government service and possibly, social control. Urban residents have greater opportunities for raising their income level than do their rural counterparts; they do not need to travel long distances to obtain education, medical care and other services. Also, their activities are more easily monitored.

To put the scale of this resettlement into global and historical perspective, it represents the greatest movement of population ever documented, far outpacing the American "Great Migration" up the Mississippi to Chicago and other northern cities at the turn of the 20th century. It also underpins a boom in new building construction. Over the next 15 to 20 years, according to David Sandalow, Assistant Secretary for Policy and International Affairs at the U.S. Department of Energy, China is expected to add 300 billion square feet of new floor space, roughly equal to all the existing commercial and residential floor space extant in the United States today.

This program of large-scale resettlement underpins two of the primary drivers for the construction of new buildings in China. First, the influx from the countryside into the cities provides a source of low-cost labor for factories, many oriented to export markets. The potent combination of a steady supply of low-cost labor and access to foreign markets has brought wave after wave of factory expansion throughout China, first along the eastern coastline then into the coastal hinterland and, most recently, along the upper Yangtze and into western China. Second, this massive resettlement program has created the need for a massive stock of new, low-cost housing. The pattern which this second trend has produced is the so-called "super-block" phenomenon in China.

"Super-blocks" are started with large-scale parcels of land, usually on the outskirts of a second- or third-tier city. (Frequently, the land appropriated for this purpose involves "dis-appropriation" by local government officials from former occupants, giving rise to one of the most common sources of corruption charges in China—namely, collusion between government officials and property developers.) Once consolidated under the direction of the local government, the basic infrastructure of water and electrical

supply, sewage, and roads is installed in what is a highly routinized, efficient and unimaginative fashion. Rights to build massive apartment complexes on these infrastructural grid templates are then auctioned out to property developers. (Frequently developers will bargain with the government to have luxury property development rights included in the final negotiated package since the high margins from the development of communities of luxury villas help offset the low margins of apartment mega-complexes built for low-income workers.) The net result of this super-block dynamic being repeated in cookie-cutter fashion in cities throughout China: the construction of 20,000 new residences and 160 miles of new residential-support roads every day. This is the scale of new construction required to absorb the 15 million people who are annually resettled in cities by the government as well as the 29 million other people who choose voluntarily to leave the countryside and go to the city each year.

In Chapter Three, we will look in detail at how cooperation between the United States and China in the area of building energy efficiency promises to improve this picture.

Smart Grids

Through the active contribution of Joint U.S.-China Cooperation on Clean Energy (JUCCCE), smart grid collaboration was one of the first topics taken up in the clean energy dialogue between the United States and China, even before the process was formalized in the S&ED process. It quickly became apparent that prospects for cooperation in this field were limited. This did not reflect competitive concerns, it was a simple reflection of different market conditions and preoccupations.

In the United States, the focus of the industry is on the "delivery end" of smart grid systems. This means smart metering and user operability. The key development behind smart metering involves various technologies—wireless and even data-transmission through the electrical line—to transmit user data back to the utility. In addition to the technology side, this also raises questions of user privacy and pricing structures needed to

encourage user opt-in. As for user operability, the focus of the industry in the United States is on "gamification" and other software-based techniques to encourage the user to more actively use and explore the capabilities of their smart metering devices.

In China, the residential and small business base of users is less able to afford devices of this type and less inclined to want to use them. The focus of the Chinese industry instead is at the other end of the business—where large-scale wind energy providers connect to the nationwide electrical transmission grid of state-owned monopoly, State Grid Corporation of China. One problem which needs addressing is that, as a result of incentive structures in China, renewable energy generation capacity has been built but not interconnected to the relatively primitive utility transmission network. Another problem is more basic. Due to natural conditions, the vast majority of wind power installations in China have been in the northwest and southwest regions of the country. However the population centers which most need this energy are located at the opposite end of the country along the eastern coastline. To address both of these challenges, State Grid is currently experimenting with a system upgrade of its entire, antiquated utility infrastructure. Plans call for the entire national grid system to be replaced with a state-of-the-art upgrade by 2020.

Electric Vehicles

Electric vehicles offer a hugely important opportunity for the dramatic lowering of carbon emissions and the development of low-carbon economies. The transportation sector generally represents almost one-third of an advanced economy's use of energy. More than 10 percent of global CO2 emissions are directly attributable to automobiles and other vehicles on the road in just the United States and China.

Electric vehicles are also a focus of cooperation for the U.S.-China Clean Energy Research Center (CERC) program. The U.S. side of this collaboration is based in Ann Arbor/Detroit and led by the University of Michigan. In the United States it is one of three CERC centers created through a joint

Obama-Hu agreement in November 2009 and funded by Congress in the 2010 budget year. The other of these two CERC centers are based in the San Francisco Bay Area (for building energy efficiency under the leadership of the Lawrence Berkeley Lab) and in West Virginia (for coal under the direction of the University of West Virginia). The Chinese government has established and funded three counterpart research and development centers in China, each paired with a sister center in the United States. The national program for supporting their respective centers was set at US $75 million over five years in each country, with the funding divided evenly among the three centers.

Because the focus of this book is renewable energy, it does not delve deeply into the transportation sector and the fuels which power it. For our purposes, the main issue with electric vehicles is that they are built around battery technologies which derive their power from the electrical grid rather than directly from fossil fuels. We will not look deeper into this important area of collaboration[14] between the United States and China other than to make the following two observations:

1) In contrast to the sophisticated battery technologies which are being developed and commercially tested in the U.S. market, most Chinese battery solutions involve simple arrays of conventional rechargeable dry-cell batteries, usually built into the under-chassis assembly. As in the solar field, there is currently a corrosive dynamic at play whereby government price supports for large scale production of these simple products in China undercuts the higher priced, more technologically-advanced ventures being launched in Silicon Valley, Detroit, and elsewhere in the United States.

2) While the United States has generally proved to be a difficult market for Chinese companies to crack, the economic distress experienced by Detroit in recent years has made it something of a welcoming beacon for Chinese investors. It has become a place where China can acquire world-class assets for a priority national effort to raise the global competitiveness of its auto industry at bargain basement prices. These deals include the sale of Nexteer, GM's steering division, to Pacific Century Motors (a con-

sortium partly owned by Beijing's municipal government) and the sale of Delphi's brakes and transmissions business to another Chinese consortium.

THE COMPARATIVE CASE: "PICKING WINNERS"

Before concluding this survey of sectors involved in clean energy, it is useful to take a quick detour for the unexpected vantage point it provides. This is the view from China's telecommunications sector.

It has frequently been noted that China, given its late start in economic development and technology deployment, has enjoyed an enviable leapfrogging opportunity. In effect, China has been able to duck much of the high-cost, low-return burden of upgrading an extensive network of fixed-lines, especially the costly "last-mile" connections to consumers and end-users. At the same time, development of the wireless industry was already well underway and China's planners were in a position to direct then-scarce dollars towards creation of a modern wireless infrastructure and less towards trying to upgrade a legacy telecom delivery system to consumers. What emerged was the rapid rollout of a state-of-the-art wireless network which helped business users and consumers plug in with their mobile devices to the modern economy. At the same time, an extensive inter-nodal network of high-speed optical cables was installed so that developers of new properties did have access to advanced fixed line telephony.

Another leapfrogging opportunity provided by the wireless industry is the rapid evolution of performance standards and protocols. Over the short 30-year lifetime of the industry, it has already progressed through 2G, 3G, and now the 4G stages of evolution. Each stage provides an opportunity for new technology innovators to establish themselves within the commercial ecology of the sector. Each stage of progression forces governments around the world to decide whether they will set standards in their home market that might improve the opportunity for their industries to prosper, both domestically and in the international marketplace. China is widely acknowledged as having seized, with evident focus and follow through, on both of these opportunities for leapfrogging. From an end-user standpoint, China has decisively favored the expansion of the wireless

industry at the expense of major upgrading of the fixed line business. It has also assiduously tried to leverage access to its market in exchange for support in developing a Chinese 3G standard for both China and international markets.

Both of these leapfrogging activities represent market interventions by Chinese national planners which are anathema in the U.S. system. In the United States, it is left to the capital markets and to the related processes of mergers and acquisitions to sort out the winners and the losers in this area. It is frequently assumed that the interventionist approach taken by the Chinese national government—rationalizing its ministerial structure[15] to allow the government to speak to the market with a clear voice; building out the commercial fiefdoms of China Mobile, China Telecom, and others to enable them to better compete with foreign firms; directing capital to high return areas of domestic marketplace; and leveraging standards—yields distinct advantage. A closer look does not bear out this viewpoint though.

In actual practice, the Chinese government's telecom play has been clever in design but largely unsuccessful in outcome. Recognizing that the United States and Europe have the world's strongest telecom companies, China has positioned itself tactically in an intermediate position between the European and American approaches, the better to learn from both and the easier to follow whichever approach offered to take them farther. In Europe, the market development pathway, simply put, involves government planners promoting an inexpensive and fully interoperable system by corralling competing carriers together and forcing them to adopt standards and a system deemed most likely to succeed. In the United States, by contrast, the government is enjoined to keep its distance from the market competition. The approach is, in effect, to let "100 flowers bloom" and let the creative destruction of the marketplace determine which flourishes and which withers.

It is readily understandable that an American consumer, frustrated by the patchwork of coverage areas and different service plans offered by companies that seem to come and go in the U.S. marketplace, would be favorably

impressed by the ubiquity and uniformity of wireless service throughout China. If dialing from a high-speed train on a trip between two first-tier "showcase" cities fresh from a conversation about Chinese government efforts to establish its wireless standard both domestically and internationally, that American might easily conclude that China has the 21st century figured out and is simply leaving the United States behind.

Scrutinized more closely though, this picture does not hold up. Closer examination shows a system where Chinese government intervention and capital outlays become tangled up in issues of national pride and the propping up of national champion firms owned by the state. Over time, this situation interferes with the ability of Chinese companies to follow the fast development of technology-driven markets wherever they lead. The government's stake can then produce an outcome where regulatory walls of protection are built to protect domestic champion firms who can profit by privileged access to the large and increasingly affluent consumer base in China but who fail to develop the innovation in technologies strengths to allow them to compete successfully in international markets. The fact that there is a large and increasingly affluent base of consumers to support China's telecom industry raises this risk rather than reduces it.

Of the two major wireless technology bets which the Chinese government has made so far, neither has gotten any traction internationally and both seem destined for eventual failure in their home market once the government swallows its pride and lets go of them: (1) China's indigenous TD-SCDMA standard for 3G mobile; (2) China's WAPI (Wired Authentication & Privacy Infrastructure) protocol for WiFi. The only betting round which China's planners seem to have gotten right in the fast evolution of the global telecom business is the bet they did not make—passing on the chance to invest in the WiMax protocol for fixed and mobile Internet access.

This raises one important question as we wrap up this survey of clean energy technologies and begin a discussion of the clean energy investment dynamics in both countries. How expert are China's national planners actually in picking winning technologies?

ENDNOTES

1 According to reports from the International Energy Agency which Beijing initially contested.

2 Illustrative of this trend, PetroChina, the country's largest oil and gas producer, announced that its crude oil and gas output in 2010 exceeded the prior year with a 3.6 percent increase in domestic output as compared to a 14.4 percent year-on-year increase in its overseas oil production.

3 *China and the Persian Gulf*, Bryce Wakefield and Susan Levenstein, eds., (Washington, D.C: Woodrow Wilson International Center for Scholars, 2011).

4 In the United States, shale gas faces market acceptance issues and regulatory scrutiny relating to the "fracking" extraction technology and concerns of possible water contamination.

5 Jesse Lee, "The U.S. and China: Towards a Clean Energy Economy," The White House Blog, November 17, 2009, http://www.whitehouse.gov/blog/2009/11/17/us-and-china-towards-a-clean-energy-economy.

6 Dominic Waughray, Senior Director and Head of Environmental Initiatives at the World Economic Forum, estimates it will take 20 years before "economic externalities" such as this are fully internalized into a new economic model with broad international acceptance.

7 It is often claimed that this windmill design was invented in China before the Christian era, however firm documentation dates the earliest known windmill in China to AD 1219.

8 Pilita Clark and Leslie Hook, "China Set to Challenge Global Wind Industry," *Financial Times*, August 28, 2011, 14.

9 "China Focus," BERC Newsletter, vol 2, issue 22, October 11, 2010.

10 Jason Dean, Andrew Browne and Shai Oster, "China's 'State Capitalism' Sparks a Global Backlash," *Wall Street Journal*, November 16, 2010, 1.

11 Some readers may recall that this is exactly the question which the business plans of Internet companies in Silicon Valley were asking before the dot-com shakeout in April 2000.

12 The preponderant share of Chinese exports went to European markets where subsidy levels were more generous than in the United States. However, just as Chinese manufacturers were ramping up 2011 production at levels of 50-100 percent above 2010, austerity-minded European governments began cutting their subsidy programs by even larger levels.

13 David JC Mackay, *Sustainable Energy—Without the Hot Air* (Cambridge: UIT Cambridge Ltd., 2008), 44. Available online at http://www.withouthotair.com/.

14 For more information see "Clean Vehicles," *U.S.-China Clean Energy Research Center*, www.us-china-cerc.org/Clean_Vehicles.html.

15 A video clip from the 2010 M.I.T. Energy Conference, "China: The Cradle of New Energy Technology" includes an excellent overview on the far-reaching ministerial rationalization which Beijing undertook in the telecom sector. Good bureaucratics, however, does not always translate into good policy. The clip can be found at www.thegreenskeptic.com/2010/06/mit-energy-conference-2010-china-cradle.html.

INVESTMENT

For U.S.-China clean energy cooperation to succeed, it will need to be scaled to a global level by investors, public and private. In this chapter, we will gauge what is needed for this to happen in the U.S.-China cleantech domain. To get there, we will first survey global sources of capital, and then compare the different systems for raising capital in the two countries. Next, we will examine what investors require of a policy regime and then see what that means for the key asset classes in clean energy in the United States and China. The chapter ends with a detailed look at the renewable and energy efficiency asset classes and includes a case study of a particular U.S.-China cooperative effort in building energy efficiency.

GLOBAL, GLOBAL, GLOBAL

Energy resources, whether viewed as grist for traditional energy investment or as the denominator of a new "climate change" calculus of investment, require a global perspective. This is because, as Bruce Kahn of Deutsche Bank Climate Change Advisors explains it, "capital is a free-flowing system. If (one country) is not an attractive place to invest in renewable energy, capital will flow elsewhere."

In this respect, the investment community aspires to a more holistic and objectively-based perspective than either the policy or technology viewpoints. The policy process, by its nature, will force "facts" to fit jurisdictional norms through political compromise. The technology development process, like a microscope, excludes much of the world from its field of vision in order to focus intensively on a small piece of it.

In contrast to both of these, the investment perspective tries to generate profit by understanding, in a global sense, where the best opportunity to make an investment is and, in an objective sense, what the parameters of that investment opportunity are. Investors will focus on national or local laws only to the extent that they are committed to generating profit from or in those jurisdictions. They will freely move their activity to another

jurisdiction if the opportunity for profit recommends that. Similarly, investors bet on particular technologies not because of their ultimate potential to improve the world,[1] but because of their potential for returning a profit, as they make the transition from the lab to the market and then are brought to commercial scale.

For traditional energy investors, the starting point is that resources are finite globally and profitability depends on the cost of access to global supply and demand. In an investment world of near-instantaneous command of data and fast logistics in moving goods to market, these investment decisions are inherently global. For alternative (i.e., renewable) energy investors, investment decisions also hinge on (a) the effects of the release of carbon dioxide and other greenhouse gases (GHG) into the earth's atmosphere; and (b) the market urgency, reflected in pricing, for addressing GHG levels via solar, wind, and other renewable sources of supply for the local market.

Non-trivially, a molecule of carbon dioxide released by any technological means, in any political jurisdiction, has a global impact in two ways. First, the effect of that molecule once it reaches the atmosphere affects the entire global system, irrespective of place or source of origin. Second, even though the social and economic impact of that molecule of carbon dioxide will eventually be felt in starkly different ways by different communities—rich versus poor; coastal versus inland; agricultural versus industrial; equatorial versus arctic—the moral challenge which it poses to our humanity, and to the sustainability of the global enterprise, is commonly shared.

The distinctively global nature of the investment perspective is important to understanding the overall dynamics of the U.S.-China relationship in clean energy. An example of this is the highly local business of water. Throughout the world, the acquisition and use of water takes place within a naturally-bounded unit of a specific water catchment area. In both the United States and China, as elsewhere, the business of water is conducted in a highly local fashion, (as a geographical fact), somewhat parochially (as an historical feature of utilities businesses in general), and—until recently—without much notice. But the investment side of the water business can be highly global.

Taking two "sister cities" as a case in point, there is a world of difference between Philadelphia in the water-rich mid-Atlantic catchment area of the Delaware River Valley and Tianjin on the water-constrained fringe of the Gobi desert. While the day-to-day business of delivering water to customers is conducted entirely locally in both these areas, the investment activity to support the sustainability of their operations has become increasingly global. A recent McKinsey & Company report[2] identified 55 critical solutions for municipal managers of the water supply in northeastern Chinese cities. The McKinsey report emphasized that over 85 percent of the needed water infrastructure upgrades offer significant potential for investment return by global investors. The limiting factor for external investment funds to service these highly local needs is simply a function of potential return on investment modified by the risk associated with the investment regime in that locality.

Of course, the more pressing problems are the greater need for investment to facilitate solutions. In China, the necessity to assure a sustainable water supply is particularly pressing:

- China has about 20 percent of the world's population but only 7 percent of the world's fresh water (with a large proportion of that water located at a distance from the country's concentration of population);
- 70 percent of China's rivers and lakes are polluted[3] and half of China's cities have contaminated groundwater;
- Industry in China uses, on average, 3 to 10 times as much water to produce a given product than industries in other advanced economies.

To put it bluntly, what water China has at its disposal comes from a distance, may be compromised in quality, and will be used less efficiently than the industrial norm.

CAPITAL AVAILABILITY FOR CHINESE AND U.S. CLEAN ENERGY INVESTMENT

The United States and China do share some notable traits in how investment capital is organized and channeled to help cleantech businesses grow and clean energy industrial sectors develop:

- Both countries rely on public sector funding (at the national and local—i.e., primarily at the state-level in the United States and at the provincial, municipal, and district levels in China) to support various clean energy initiatives;
- Over the past three years, government-directed, post-crisis "stimulus spending" in both countries has been particularly important to the promotion of their respective clean energy economies;
- At the market level, both economies rely on a combination of three different types of investment and financing to promote technology research, development, and market-scale commercialization in cleantech:
    a) Asset financing or "project financing,"
    b) Public market financing, including IPOs;
    c) Venture capital and private equity (so-called "alternative investment") financing;
- In both countries, non-public money is an important pillar of clean energy industry development.

While the two countries thus raise capital for cleantech investment in similar ways, it is important to establish as a yardstick the absolute size of this activity in both and to spotlight the differences in relative importance of the various features of each system:

First, in absolute terms, the overall level of investment (public and private) in China for clean energy has nearly doubled the equivalent U.S. investment level for the past two years.

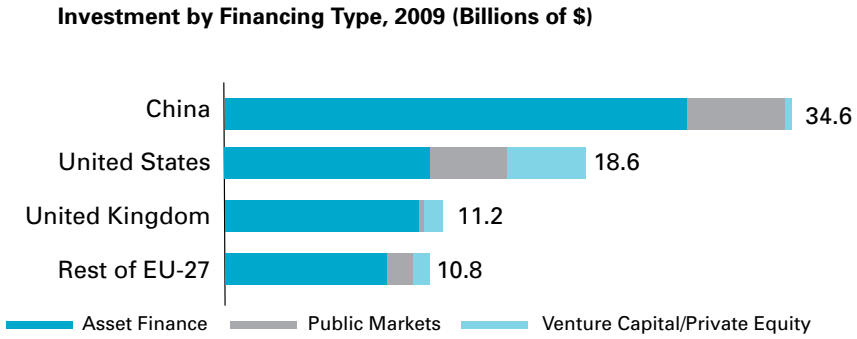
2010 Rank	Country	2010 Investment (billions of $)	2009 Investment (billions of $)	2009 Rank
1	China	54.4	39.1	1
2	Germany	41.2	20.6	3
3	United States	34.0	22.5	2

Source: Pew CCC's Who's Winning the Clean Energy Race

Nor is this two-year performance likely to be an anomaly. According to a study by the Pew Charitable Trusts, China is expected to continue to outpace the United States in cumulative investments through the entire 2010-2020 period, with China making a cumulative investment over this period of US $471 billion versus an expected U.S. cumulative investment of US $245 billion.[4]

Second, the stimulus spending which the two countries unleashed in the wake of the GFC differed in both relative scale and how the money was spent.[5] China, with an economy only 40 percent the size of the U.S. economy, put together a US $585 billion stimulus package, almost three-quarters the size of the U.S. package. Almost half of the Chinese spending was directed to infrastructure projects (principally, transportation and energy infrastructure) while only 12.5 percent of U.S. stimulus spending went to infrastructure (and twice that amount went to one-time tax cuts or rebates).

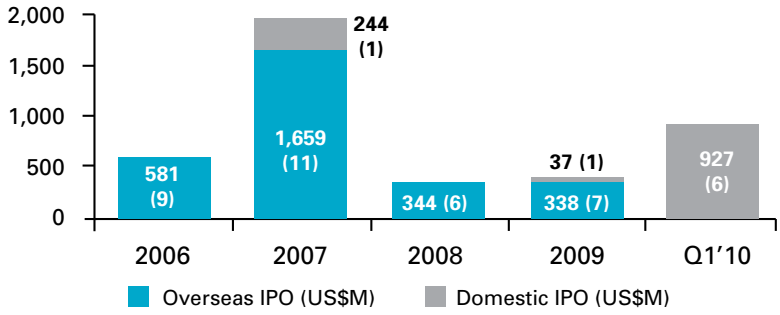
Third, the relative reliance on different channels of investment mobilization to support clean energy is clearly different in the two countries. China relies on project-style "asset financing" (much of it led by local governments) whereas the United States puts much greater reliance on the fully-private sources of venture capital (VC) and private equity. The chart below compares investment by all principal types. It shows that China leads with project/asset financing (dark blue) and that the United States is comparably stronger in the alternative investment categories of venture capital and private equity (light blue).

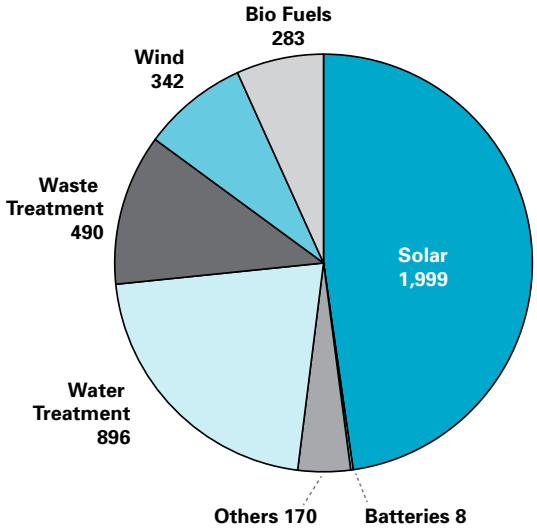


Finally, both countries rely significantly on non-public money to support the build-out of their clean energy industries. It is clear from the above graphic that U.S. reliance on the venture capital and private equity markets is significant. In China, the picture is more nuanced. The Chinese venture capital (VC) market is much less developed than in the United States but, in the post-GFC environment, the Initial Public Offering (IPO) market recovered much more quickly than in Western economies, giving a boost to China's VC sector. On the other hand, the private equity industry in China is still embryonic and, such as it is, mostly controlled by "princelings" of the CCP ruling elite. It is therefore, less than fully private and quite hard to measure. With these fence-posts staked to delimit the field, the following graphs by Ken DeWoskin of Deloitte Touche Tohmatsu (China) gives an outstanding overview of the scale and scope of non-public money in China's cleantech sector.

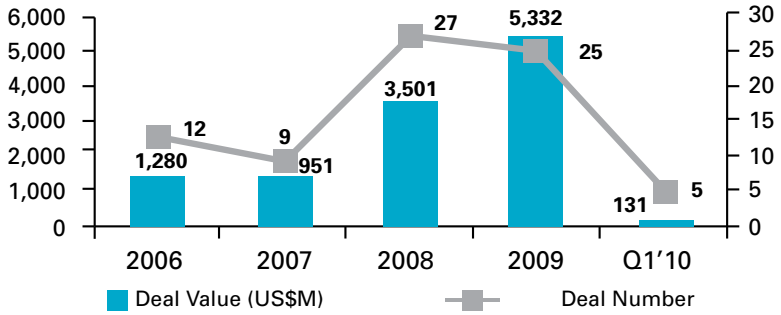
NON-PUBLIC MONEY IS THE PILLAR OF CLEANTECH SECTORS

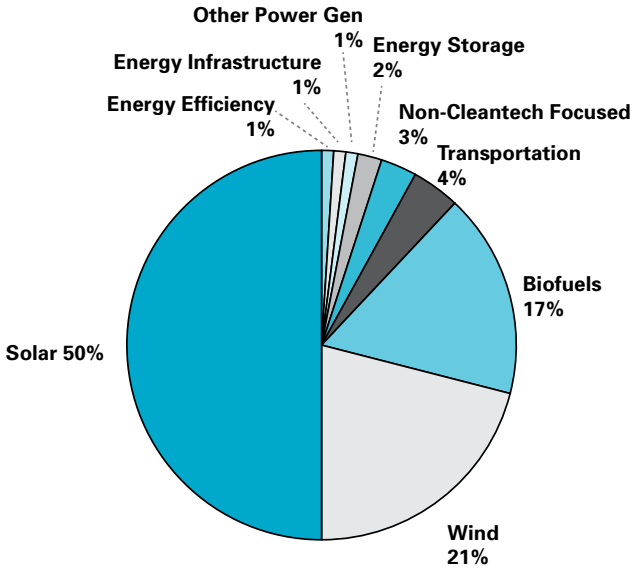
Chinese Clean Tech Companies IPO Raised (2006-Q1/2010)





Chinese Clean Tech Companies IPO Raised (2006-Q1/2010)





In 2009, China/HK accounted for both the greatest value globally from clean tech IPOs (69 percent), more than double the U.S. (26 percent) and 53 percent of deals too (17 of 32).

THE UNITED STATES AND CHINA: DIFFERENT SYSTEMS FOR INVESTMENT FINANCING

It is useful to pull back from this tight focus on current capital availability for clean energy investment and to look at these "facts" from a broader perspective.

In the United States, the deep and broad capital markets are in government-regulated, privately-held hands. They function to provide capital to predominantly privately owned companies and to facilitate the governance of those companies through the sharing of financial information and through active monitoring of corporate performance. In China, no markets of this sort existed 30 years ago and the markets which have developed since that time remain narrow and shallow, a fact that has made itself known to American investors. The vast preponderance of investment capital in China is still controlled by the national government which primarily directs it to the market through provincial governments, municipalities, and, through state-owned banks, to other state-owned enterprises.

As summarized in the authoritative *China Greentech Report:*

> *Despite strong policy support and government funding, greentech financing in China is limited by the relatively early stage of development of the country's financial markets. Compared to the developed markets, there are generally fewer options in China for raising debt or equity capital across the life cycle of greentech solutions. Greentech investments also often have unique characteristics that complicate financing, such as high front-end capital needs and long payback periods.*[6]

The reasons that options for cleantech financing are limited in China is readily apparent when one compares the financial systems.

The largest market for financing in the United States is the bond market, where governments and established companies can raise capital in return for the issuance of debt securities, usually in the form of "bonds." Aver-

age daily trading volume in the United States is US $822 billion and the U.S. bond market transacts almost 40 percent of all bonds traded in the global system. China, by comparison, is tiny with corporate bond issuance at roughly only 1-2 percent of U.S. levels. Domestically in China, corporate financing via debt tends to be handled as loan transactions by a small number of state-owned banks, rather than as market transactions mediated by countless private-sector broker dealers. (Obviously, debt-based financing of corporate investment carries different levels of "systemic risk" under these two very different systems). Internationally, China is also beginning to encourage the issuance of yuan-denominated bonds in the Hong Kong market. These so-called "dim sum" bonds are part of China's move to make Hong Kong an international center for trading China's currency. Currently, however, domestic Chinese companies will be allowed to raise, in total, no more than 50 billion RMB through this mechanism.

A second major source for funding for energy companies and established cleantech firms is the stock market, where "equity" shares in a company are bought and sold on the basis of valuations of future profitability agreed upon between buyers and sellers. Since the late 1980s, China has successfully created stock exchanges, futures exchanges and even "carbon exchanges" in Shanghai, Shenzhen, and elsewhere. However, since foreign investors are only permitted to participate in the Chinese stock market through a circumscribed and usually disadvantageous mechanism called "Share B" issuance, the stock markets in China have remained less than transparent and far more volatile than major exchanges elsewhere.

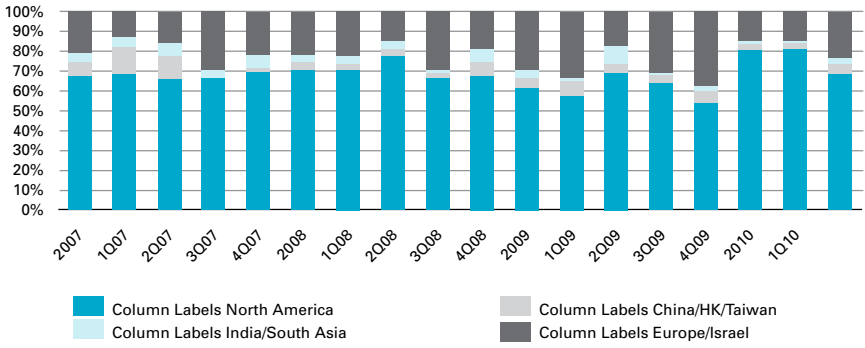
Since cleantech companies, as an asset class, are young and not fully market-tested, they rely heavily in both the United States and China on alternative investment pools of capital. In the United States, "alternative capital" refers to well-differentiated and somewhat overlapping ladders of (a) venture financing for private companies (angel, early-stage, mezzanine, small-cap, mid-cap, et cetera) leading either to the company becoming publicly-owned via an initial public offering or to mergers and acquisitions, and/or private equity transactions; (b) private equity transactions, in which

privately-raised funds are used to take a publicly-listed company private or to buy a privately-owned company for the purpose of increasing its value and realizing profit on its later sale; and (c) hedge fund transactions which involve "a private, aggressively managed investment fund utilizing sophisticated strategies in both the international and domestic markets designed to offset losses during a market downturn and/or generate higher returns than traditional stock and bond investments."[7]

In China, as the country's wealth has expanded rapidly in recent years, government planners have moved fast to diversify the sources of investment capital and thereby lessen the burden of capital accumulation on the national government. The experimentation with alternative investment-style vehicles in China started earliest, and has developed farthest, with venture capital-type structures. Begun with active assistance from Taiwan venture capital investors in the late 1990s and assisted by ChiNext and other exchanges in China where venture capital investments can go public through an initial public offering, the venture segment in China has become broadly similar to the U.S. model though much smaller in its scale of funding.

World Net Electricity Generation from Nuclear Power By Region, 2007-2030 (trillion Kilowatthours)

Geographic Share of Cleantech VC Funding



Source: CleanTech Group, 2010 Investment Monitor

Private equity models of alternative investment are far more embryonic. At the non-institutionalized level, individual "private equity" investors have been raising their profile in recent years. These individuals tend to be located in or closely connected to Beijing, many have received Ivy League or elite MBA training in the West, and frequently are the off-spring ("princelings") of high-ranking government officials.

At the more institutionalized level, a government-led effort to organize a fund structure for Chinese private capital got underway in late 2009. Currently, one major fund—the GuoChi ("Support Country") Fund—has been established in Suzhou. By early fall 2011, new investment rules are expected to be announced in Beijing, Shanghai, and Tianjin allowing foreign invested venture capital entities (FIVCE) to raise and manage private capital funds in association with designated Chinese partners. In China, there are virtually no hedge funds although quite a few hedge funds are active just across the border in Hong Kong.

For the "alternative investment" class in general, it is useful to keep in mind the "fallacy of perceived similarity." Just as Robert Whiting incisively showed with Japanese baseball, surface similarities in the form and even the outward rules of the game in no way mean that the game is played in Japan the same way it is in the United States. Particularly in the domain of "private equity," the game in China is played very differently from Western markets. Who you know tends to trump what you know.

Policy Toolsets for Investment

Given the less than fully transparent state of affairs, when an investor looks at a given policy regime insofar as it affects a potential investment in either energy production or carbon mitigation, he or she tends to examine it in a very specific way. A policy regime has essentially three toolsets at its disposal to encourage energy production in a more carbon-neutral manner. The investor will want to gauge which regime is operative at a given investment locale and how transparently and consistently that regime will be backed by government policy makers.

First, there are the tools of traditional regulation which include mandated standards, (such as those California used in 1975 to mandate the use of catalytic converters in cars) and public education (such as educating the public on keeping their tires properly inflated to improve mileage).

Second, there are various systems of carbon pricing. The cap-and-trade system, allegedly born in the mind of a Reagan White House lawyer while hiking up Cadillac Mountain in Maine and which failed at the global (COP) level in Copenhagen in 2009, is one such system. Some specific institutional arrangements such as (a) a Clean Development Mechanism (CDM) of carbon-based credits for pollution abatement, and (b) carbon exchanges, structured like stock exchanges for the purposes of trading carbon credits and also based in Beijing, Shanghai, and Tianjin, are effectively tied in to the overall design of the cap-and-trade system. Another more streamlined system of carbon pricing, favored by many economists, is a straightforward tax on carbon. While simple in principle, this approach is strenuously opposed by utilities and carbon-intensive manufacturers in the United States.

The third major toolset available to policymakers is in the area of innovation promotion. Traditionally this has been pursued through either knowledge management or adjustment assistance approaches. Knowledge management involves the vigorous promotion and protection of the rights of patenting, copyright, and trademark that support the innovation process. Since invention and innovation do not stop at national boundaries, this policy toolset also requires undertaking negotiations and entering into agreements in the international arena in order to extend protections in these markets. With protection comes greater innovation.

In the United States, adjustment assistance approaches have over recent decades tended to be politically controversial precisely because they are viewed as a form of industrial policy and involve the government "picking market winners and losers." In the early 1990s, under the pressure of Japan's economic rise and mounting fears in the United States of "Japan as number one," the Clinton administration experimented with various forms of adjustment assistance for the beleaguered automotive industry as well

as making proactive efforts on behalf of the machine tool, supercomputer, wireless, and other industrial sectors. As the competitive challenge from Japan faded in the mid-1990s, enthusiasm for this type of strong-arm industrial policy also waned. However, with the rise of China as a new economic competitor to the United States globally, there have been new moves arising in the United States in both the knowledge management area (vigorously contesting China's "indigenous innovation" policy) and in the adjustment assistance area, (experimenting with a new, collaboration-driven model of "lean" innovation suited to an era of federal budget pressures). These approaches may well expand.

The "TLC" Framework for Global Investment

With this policy toolset available for examination, the potential investor can focus his viewpoint into a relatively simple formulation. One example is what *Climate Change Advisors*, the group within Deutsche Bank that manages the financial aspect of climate change, calls "TLC."

The "T" in "TLC" represents transparency; the " L" stands for longevity; and "C" both certainty and consistency. We will look at each of these investment criteria as they apply within both the United States and Chinese frameworks for clean energy investment. Surprisingly, we will find that the scorecard is more mixed than conventional opinion might hold.

Transparency suggests a system that is easily understood and open to all. In terms of political will, as manifested at the national level, China's system is easily understood and commendably transparent. As already seen, five-year plans covering the 2006-2011 and also the 2011-2016 periods spell out, (both in broad brush and at some finer level of detail), the direction and key priorities of national planning. These priorities are not likely to change and the leadership's ability to realize them is largely assumed. Consistent realization of the objectives of earlier plans, continuation of the central leadership's extraordinary powers of resource mobilization and policy direction, suggest that the country's current plans for clean energy development are close to accurate.

But transparency also suggests a system which can arbitrate even-handedly, on the basis of well understood and generally accepted principles of fairness and full command of pertinent information, when conflicts arise in a complex and evolving industry such as the cleantech sector. Here there is less reason for confidence in the effectiveness of China's system. The question is whether a party-dominated system of authority can quickly replicate protections and disclosure rights that ensure rapid access to the investor of frank and appropriate information about his or her investment.

The TLC framework helps throw into relief why the absence of a national framework for the adoption of renewable energy inhibits the United States. The "renewable portfolio standards" (RPS) programs[8] of individual states does take up some of the slack but the federal gap is still yawning. Similarly, the TLC framework makes clear that global capital could abandon China's program to adopt renewable energy just as quickly as it has amassed to support it. The decisive factor under this scenario will likely not be the degree of national political will to support renewables but instead some more indirect factor such as deflation of China's real estate market or international backlash against China's "export machine."

The "Climate Change" Calculus of Investment

From an investment standpoint, there are six main categories of investment activity that can have an impact on climate change. To maximally mitigate global warming, all six are needed; however, not all six yield the same level of returns. The six broad categories are: (1) the development of renewable electricity and fuels; (2) the promotion of energy efficiency and conservation methods; (3) the expansion of nuclear power; (4) the adoption of CO2 capture technologies; (5) "fuel switch" policies (such as transitioning from oil to natural gas); and (6) conservation steps involving improved stewardship of forest, soil, and water resources.

Investment capital abhors uncertainty and many of these approaches to mitigation involve less than absolute promise. Carbon capture and sequestration technologies receive a large amount of federal research support

precisely because they are promising but do not currently offer any quantifiable return on investment within a 30-year time frame. Turning to nuclear energy, the investment outlook may vary greatly from national market-to-national market with the risk factor in each market reflecting the national degree of political will and public support for that technology based on current perceptions of the level of safety it embeds in that country. Human lapses and acts of nature have frequently come together—most recently at the Fukushima plant in the Tohoku region of Japan—to remind investors just how uncertain these investments can be. For instance, major governments subject to direct, popular election have, in the wake of the Fukushima disaster, mostly been moving to either freeze future development (e.g., Japan and the United States) or roll back current installations (e.g., Germany) of nuclear power generation. In China, not as accountable to the whims of the electorate, there has been a post-Fukushima directive to pause the 50-plus nuclear installations either under construction or in an advanced design stage for a review of their safety design. But there is no serious expectation that this gargantuan nuclear development program will be significantly scaled back or substantially delayed.[9]

In the United States and China, both the "fuel switch" and "forest and soil" approaches are largely subject to government regulatory action. In the United States fully one-third of corn production has been diverted to ethanol fuel production despite concerns that this approach is being driven more by a lobbying effort than by a sound, long-term environmental investment case. Similarly, Texas and Pennsylvania now lead the nation in large-scale exploitation of shale gas reserves, a development which could significantly reduce the nation's dependence on oil. Yet this approach continues to generate doubt among consumers and investors in lieu of a better understanding of the possible effects of "fracking" technology on water tables. In China, agriculture may be emerging as one of the most promising fields for investment.[10]

The two approaches generating the most interest from investors therefore tend to be the renewable electricity and energy efficiency sectors. In

the remainder of this chapter, we will take a close look at each of these two asset classes for what they reveal about the different investment environments in the United States and China.

Renewables as an Investment Asset Class

While renewable electricity sources such as wind generated and solar generated power have yet to reach so-called "grid parity" in comparison with the prices of traditional carbon-based sources such as oil and coal, the underlying trends are favorable and quantifiable in an investment sense. As we partially saw in Chapter Two, the installed cost of electricity generated by photovoltaic solar has dropped from a price of almost US $5/kWh in 1978 with "single crystal, evaporated contact" technologies to a price of just over US $0.20/kWh with new, more advanced technologies. Given that "grid parity" currently ranges from US $0.07/kWh for wholesale coal electricity up to approximately US $0.18 /kWh for retail natural gas electricity, solar is clearly well on its way to becoming a price competitive option for consumers. This path may accelerate as prices drop with the expansion of installations from today's small base to what is projected as fully 7 percent of global generation by 2020. This same trend holds true for wind generated power. Figures from the American Wind Energy Association and from Bloomberg New Energy Finance show that the capacity of U.S. wind-energy installations is expected to grow steadily.

From a strictly technological standpoint, solar and wind energy both represent attractive investments propositions, though for different reasons. In the case of PV solar, the technology has seen decades of advances with regularity similar to Moore's Law, an unsurprising fact given similarities in the manufacturing process for semiconductors and photovoltaic cells. By extrapolating three decades of steady advancement into the future and factoring in the expected expansion of photovoltaic's installed base, the price of a kilowatt-hour of solar-generated electricity in 2020 should be less than that of a kilowatt-hour of coal-generated electricity today. When one takes into account that oil prices are expected to increase sharply, and coal prices moderately, over the coming decade, the attractiveness of solar energy as

a technology over a defined investment timeframe is clear. Likewise, the generally positive experience with the large base of wind turbines already installed, the declining price-tag over the past few years for new installations, as well as the steady stream of incremental improvements in system design (yielding quieter performance and more compact profile) all point to further market-acceptance of this already well-established renewable energy sector by operators, utilities, the general public, and investors alike.

The technology developments described above in solar and wind power generation are at the heart of a broad global trend. For the past 10 years, the global share of renewable energy, as measured by new electric power capacity, has grown steadily at the expense of traditional power generation. In the 10-year period from 2000 through 2009, the share of new electric power capacity generated from renewable sources rose globally from 18 to 47 percent, while the share contributed by traditional sources fell from 82 to 53 percent.

Comparison of U.S. and Chinese Systems for Investment in Renewables

All of these trends are favorable from an investor standpoint regarding the renewable energy asset class. The challenge for investors is that the return on their investment may also be affected by other factors not so easy to project into the future. Chief among these is the policy framework which national governments and local jurisdictions (principally U.S. states and Chinese provinces) employ to promote innovation and investment in these sectors. When governments intervene to help bring a new technology to scale (for example, when the price of renewable forms of energy achieves grid parity with traditional carbon-based forms of energy), they generally do so with the help of an array of tax breaks, subsidies, and policy supports. While tax breaks and subsidies and policy supports do tend to contribute directly to the bottom line of the companies developing these technologies, they entail a number of risks.

To the enterprising company, there is the risk of un-predictableness—the

risk that a tax break, subsidy, or policy support upon which the company relies for its viability might suddenly and arbitrarily be removed. There is also the risk of complacency—the risk that reliance on one of these forms of government support might actually insulate the company from the market-attuned responsiveness which helped drive its entrepreneurship in the first place. There is also a social risk. By providing price support to renewable energy sources, the government is intervening in the market and effectively picking winners and losers. Since this approach allows government decision-makers—rather than the market, its experts, and its capital flows—to determine which technologies prosper and which flounder, there is an attendant risk of unfavorable outcomes and public backlash.

Weaknesses of the U.S. System

Despite what was just discussed, the number-one criticism leveled at the U.S. system is the lack of an appropriate national framework to promote renewable energy and energy efficiency. When the U.S. federal government does provide a policy framework and/or financial incentives, it is generally done in piecemeal fashion, over short and/or unpredictable time frames, and with little sense of national priority.

For all the reasons we have examined earlier in this chapter, such an untethered situation is anathema to investors for any investment not confined within a single state border.

Here are some of the dimensions of this problem:

- Jesse Jenkins, Director of Energy and Climate Policy at the Breakthrough Institute, has pointed out that, "over 70 percent of the federal policies and funding support for clean energy that catalyzed the recent growth of the industry is expected to lapse in the next three years or has already expired."

- The *Financial Times* reported that as a result of the tax deal worked out between President Obama and congressional Republicans in December 2010, the business sector is warning that "renewable energy indus-

tries in the United States face falling off a 'cliff,' with the loss of tens of thousands of jobs, if investment grant projects…due to expire by the end of the year…are not extended by Congress."

- A Congressional Research Service report on green energy programs and policies in China and the United States stated that in the United States, "Federal policies exist to provide corporate tax incentives for renewable energy but these are *generally authorized for short periods and must be periodically reauthorized."* [11] Elsewhere in the study it is noted that, "the history of energy research and development in the United States in the closing quarter of the last century can be described as being driven by energy prices, *causing shifts in the direction of policies, programs, and levels of program funding."* [12]

While many state-level governments have managed to provide a clear regulatory and incentive structure within their states, this has not effectively filled the national-level void for U.S. companies. Many complain that the incentives for doing business in China are clearer, greater in scale, and more consistently implemented than in the United States. A look at the ups and downs of the small car market in the United States over the past several decades shows the flightiness of the environment there for serious energy conservation consideration.

A second critique of the U.S. system focuses on the lack of access to public markets for the renewable energy asset class in the United States. Why don't public markets in the United States support the financing of renewable energy? It is not from a lack of financially attractive returns. As insightfully explained by Richard Kauffman, Chairman of Levi Strauss,[13] there are two inter-related reasons.

First, under current legislation, renewable energy project developers are restricted to private sources when they are seeking tax equity partners. Even with support in the form of government tax credits, most renewable energy projects do not generate sufficient cash flows in their startup years to create a "currently yielding investment for public equity investors." This

effectively bars them from the largest available source of non-governmental funds.

Second, there are not standardized contracts. Absent a source of large pools of public debt to attract investor interest, there is little incentive for equity providers "to help standardize contracts to help establish a bond market" for the renewable asset class.

A third critique, persuasively voiced by Bill Gates, points to chronic underfunding by the U.S. government in the energy sector as compared to other sectors, such as healthcare, where U.S. government funding to support innovation is much higher and generally uncontroversial on Capitol Hill. Through his membership in the American Energy Innovation Council, Gates has called for a national energy policy that would "increase U.S. (government) investment in energy research every year from US $5 billion to US $16 billion. Gates candidly states that he was "stunned" that the U.S. government invests so little in energy research. By comparison, the National Institutes of Health invests more than US $30 billion annually in healthcare research, development, and innovation.

Weaknesses of the Chinese System

Notwithstanding its much better reputation for national level direction and implementation of clean energy policies and incentives, the Chinese system too has some glaring weaknesses.

- The speed with which Chinese government policy has encouraged growth of the clean energy industry is one such weakness. As described by a senior researcher in the State Council's policy research center, Chinese government policy, by "encouraging new industries, hopes to catch up with developed countries, but the methods used are wrong. New energy industries require huge investment in terms of both capital and technology. The thresholds set by the government for entering the industries were too low. Many traditional industry manufacturers, attracted by the prospect of high profits, swarmed into the new energy sectors. They have neither enough funds nor the necessary

technology to develop creative products."[15]

- Directly related to this is the danger of overcapacity in China's emerging energy industry. He Shihong, head of the China Finance Research Institute, points to signs of imbalance and "blind development" showing up nationwide in the emerging energy industries, citing 18 provinces and major cities with announced plans to make clean energy a "pillar for future development."[16] Nicholas Lardy of the Peterson Institute for International Economics has been one of the few American observers pointing out this particular risk in China's clean energy sector.

- More generally, state control over its huge infrastructure markets (power generation, transportation, water/wastewater, et cetera) can be either a blessing or a curse, depending on market conditions. As long as strong growth is maintained in the overall economy, the playing field is attractive to both incumbents and outsiders (and the government can tilt the field in favor of domestic suppliers). However, in an abrupt market slowdown, risk can expand rapidly as a result of the pervasiveness of government control. In a situation where state-owned utility companies are buying electricity from state-owned energy development companies, which are in turn buying their power equipment from state-owned manufacturers, the risks of over-leveraged investment in a commercially-still-unproven industrial sector are appreciable and self-referentially magnified. These risks could quickly show up if China's unprecedentedly large stimulus spending package—especially its hypergrowth of spending on infrastructure and the super-heating it led to in real estate markets in the wider economy—should be followed by a "hard landing" of the economy.

- Finally, it is far easier to play catch-up in the global technology arena than it is to maintain front-runner position over the long-haul. We have seen how China's industrial development strategy for telecom has stumbled in this respect, even in its own domestic market. Similarly, we can see how China's attempt to use its market position to strong-arm

the raw material of innovation—"intellectual property"—away from foreign companies through its "indigenous innovation policy" signals clear weakness in this area. As China's investment in clean energy continues to outstrip the United States and European nations, the risk of China's losing balance on the question of national prestige versus demonstrated returns-on-investment will only grow. [17]

Stepping Back for an Investment Perspective

There is no question that China's national policy and system of incentives for promoting clean energy has led to extremely rapid development—and correspondingly high levels of investment—in China's renewable energy sector in recent years. Similarly, there is no question that a national framework to support the development of the renewable energy sector has been lacking in the United States. Furthermore, the lack of a "TLC" framework for investment in renewable energy has also held back this sector in the United States.

As a result of these twin facts, investment dollars have tended to be redirected from the U.S. market and to flow toward the Chinese market, precisely as Deutsche Bank Climate Change Advisor, Bruce Kahn explained at the outset of this chapter.

While it is tempting to extrapolate and try to draw conclusions about what this situation means for the future, we still need to look at the other sector of this asset class which has attracted major investment interest—the less glamorous but high-performing sector of energy efficiency.

Energy Efficiency as an Investment Asset Class

In contrast to an easy-to-visualize investment in a company which is harnessing wind or one of the other forms of renewable energy to generate electricity at utility scale, investments in wringing out energy efficiency savings from across the spectrum of industrial, commercial, and social domains seem less clear-cut. One candidate for investment within this asset class might be a service company which provides energy audits for resi-

dential and/or commercial property owners. Another candidate might be a startup company with a specialized fuel additive to help commercial fleets realize higher mile-per-gallon fuel performance or a software product to more efficiently manage a corporate fleet.

Two basic facts about this asset class are noteworthy for our purposes. First, the United States has consistently outperformed China over the past 10 years in this type of commercial activity. This is reflected both in levels of investment associated with this asset class and also with the comparatively larger share of productivity gain which the U.S. economy has gained as a result.[18] Second, it is where the highest returns on investment have tended to be found in the entire "climate change calculus" of investment. As Parker Weil, co-head of the Americas Energy and Power Group at Bank of America Merrill Lynch, puts it:

> *We are bullish on energy efficiency. A famous criminal was asked why he robbed banks. He said that's where the money is. Energy efficiency is where the money is. It is where projects are cash-flow positive. It is where capital can be attracted because the paybacks are attractive.*[19]

Since this asset class is so varied, the best way to illuminate it—and to reveal an important nexus of U.S.-China clean energy cooperation—is to look at a particular case in point.

CASE STUDY: BUILDING ENERGY EFFICIENCY AT THE REGIONAL, NATIONAL, AND INTERNATIONAL LEVELS AND ITS ROLE IN U.S.-CHINA COOPERATION

As we have seen throughout this chapter, attracting renewable energy investment to areas that bring national benefit is inefficient in both China and the United States, though for differing reasons. Might it be possible for the two governments to collaborate and thereby correct for each other's failings?

A closer examination of the new energy efficiency hub in Philadelphia and, later, the joint U.S.-China Clean Energy Research Centers (CERC) at Lawrence Berkeley Lab and Tsinghua University offers a case study in how some of this collaboration might happen.

The hub in Philadelphia showcases the lean innovation policy model by focusing on energy efficiency in buildings. This is the only area of technology innovation that is included in both the Energy Innovation Hub (EIH) process and the bilateral U.S.-China Clean Energy Research Center (CERC) process and is therefore particularly appropriate as a case study. That it also throws light on the chicken-and-egg investment challenge that constrains the flow of funding into this key area of potential energy savings is a bonus.

The Energy Innovation Hub (EIH) in Philadelphia, called the Greater Philadelphia Innovation Cluster, or GPIC, is a US $159 million collaboration led by a multiagency federal government initiative and that also involves a public/private collaboration of governments (state, city, and local), companies, and nonprofit organizations. Its twin goals are (1) to double the energy efficiency of commercial buildings in a 10-

year period and (2) to create high-quality jobs and promote investment in the local clean energy economy. These goals are to be reached, assuredly, through the development of advanced technology tools but, most importantly, it is the development of a new more integrated approach within the building sector that will be key. The technology pieces of this puzzle are straightforward and led by the private sector. A task force led by IBM is in charge of a program to develop a more powerful set of computer modeling tools. Similarly a second task force led by United Technologies Corporation is in charge of devising new technology tools for integrated management of the building energy systems, from the planning and design, through to the construction management, and monitoring stages.

Atypically among the three national energy innovation hubs, the primary challenge for the GPIC does not fall in the technology domain but instead involves a complex mosaic of policy impediments, industry structures, business practices, and consumer behaviors. In fact, technology solutions are already available to improve energy efficiency in the region's existing stock of office buildings by a full 30 percent so it is not simply a question of technology. The barriers to realizing greater energy savings are principally organizational and human-based. Some of these barriers are the fragmented way in which the building trades have historically evolved and interact with one another today; the ways in which building efficiency is hampered by outdated standards and codes; the ways in which investors are deterred from improving the building stock by financial and tax considerations; and the ways in which operators, owners, and consumers fail to understand or act to optimize energy efficiency.

These features of the building and construction industry are thrown into relief by comparison with the automotive and aerospace industries. These two transportation sectors are organized in a highly efficient, vertically integrated manner. For instance, a decision by the CEO of Boeing to decrease its carbon footprint by X percent within a specified time frame quickly transfers through the company's entire supply chain so that, through an integrated process of collaborative management, the various suppliers are able to work out their shares in contributing to this company goal. The building industry is at the opposite end of the industry spectrum. It is organized through highly fragmented sequences which start with architects and designers, move on to include developers and construction companies, then real estate owners and management companies before ultimately coming under the purview of facility operators and maintenance personnel. Under this system, a decision to decrease carbon emissions or to increase energy efficiency cannot simply be issued and acted upon because there is no vertical hierarchy. The goal has to be separately negotiated with each link in the entire chain of industry organization. More challenging still, each link in the chain is acting to maximize its own profitability and to limit its own liability. This non-integrated scenario helps explain why available energy efficiency technologies do not often become widespread or fully utilized.

The overarching goal of the GPIC is to harness, through collaboration, the best thinking of all "users" of buildings—including those who build, use, and regulate them—to develop a more integrated regionally-based model for the industry. The initial regional focus of this national initiative represents a new line of thinking for the federal government. The U.S. Department of Energy, the principal cabinet-level agency responsible for setting energy efficiency policy, has traditionally tooled policy at a national level. However different climate conditions across different regions of the country require different efficiency so-

lutions. Also the housing stock of Boston is of an entirely different vintage and makeup from the buildings in Phoenix. What's more, real estate is all about location and the business of real estate tends to operate in a highly local fashion. For all these reasons, the Department of Energy mandated that the newly created National Center for Energy Efficiency in Philadelphia focus initially on developing a regionally-based model. Once that regional model is demonstrated and validated, the program calls for the solutions to be "scaled" nationally with regional tweaks to take into account regional variation.

With this background on one instance of the Energy Innovation Hub (EIH) national framework for energy innovation, it is revealing to compare and contrast the U.S.-China Clean Energy Research Center (CERC) program. For one thing, the bilaterally focused CERC program is naturally smaller in scale than the national program. All three U.S.-based CERCs (located in Berkeley, CA; Detroit, MI; and Charleston, WV) are each funded at a five-year-level of US $25 million in comparison with five-year funding in excess of US $125 million for each of the energy innovation hubs such as the GPIC. Also, the scope of collaboration is different. As just outlined, the goal of the national GPIC hub is broad and transformational—developing an innovative, regionally-based model of national significance through increased integration of the region's building industry. The goals of the CERC collaboration are necessarily more limited, focusing on specific technology areas where the United States and China can both gain through co-invention, co-development, and co-commercialization of building efficiency technologies. Thus far, the collaboration between the Lawrence Berkeley National Lab and Tsinghua University's Building Efficiency Research Center (BERC) involves six technologies: advanced monitoring and simulation; building envelope technologies; building equipment; cool roofing materials; whole building efficiency; and windows and day-lighting technology. In addition, there is collaboration

on commercialization and policy analysis between the two countries. Clearly this is a more narrowly based effort than the national undertaking. One reason this is to be expected is because areas of collaboration between the United States and China must be thoroughly vetted by U.S. industry for competitiveness concerns. In addition, protocols must be worked out for the protection of intellectual property developed through the process as well as for commercial rights to products and services eventually brought to market as a result of the collaboration.

While the overall scale and specific scope of these two programs at the U.S. national and U.S.–China bilateral levels are different, they share important features in common. For one thing, both are cut from the same intellectual cloth. As we saw in Chapter One, Michael Porter's pioneering work in the early 1990s drew attention to regional innovation clusters as a driver of economic growth at the national level. During the lead-up to the 2008 election, the Brookings Institution further developed Porter's thinking for policy implementation. The main workshop where this was done was the Metropolitan Policy Program. At the Metropolitan Policy Program, the blueprint for clean energy innovation cluster policy was initially developed as incorporated into the FY 2010 budgets of the Department of Energy and five other federal agencies (and as eventually championed by President Obama in his February 3, 2011 speech at Penn State University). A competition was held, based on the basis of a discerning Request for Proposal. "Subnational" regions around the country were invited to compete for these national grants on the basis of the quality of their proposals as well as on the basis of their track record for pioneering research and successful commercialization.

But this "cleantech innovation cluster" thinking also spilled over from the Metro Program at Brookings to help inform policy proposals being hammered out to address policy conundrums with China at Brookings'

John L. Thornton China Center. This same blueprint informed the architecture of "sub-national" level CERC linkages between leading cleantech centers in the United States and China. As eventually incorporated into the official U.S.–China Strategic and Economic dialogue process, the Brookings feature of "sub-national partnership" between cluster areas in the United States and China became a bedrock feature of "the Roadmap." Once the framework for regionally-based, nationally-scalable innovation and public/private partnership was set, capital began to test both the objective parameters of the regional model and its scalability at the national level and its applicability at the global level.

This mobilization of capital in partnership with energy innovation objectives is particularly noteworthy at the Philadelphia Energy Innovation Hub (EIH) for two reasons: (1) it is unique among the three original EIHs for having a mandate to create jobs and promote investment shared among six federal agencies including the Small Business Administration and the Economic Development Administration of the Commerce Department; and (2) it is the only national-level EIH to share a common scope of work with a CERC center—namely, the Lawrence Berkeley Lab and Tsinghua University CERC, for building energy efficiency.

As one of the first validations of the "cross-connect" between the GPIC Energy Innovation Hub and the Lawrence Berkeley Lab/Tsinghua University CERC, an advanced lighting technology, (first pioneered at Tsinghua University under CERC auspices), is now being installed at the Philadelphia Navy Yard, home of the Greater Philadelphia Innovation Cluster (GPIC).

In recognition of this two-fold potential for pioneering energy efficiency financing and for cross-connecting to the China market, capital is being pooled and companies being formed in and around the GPIC. This fact was duly recognized in July 2011 when the Brookings Institu-

tion released its first "Sizing the Clean Economy" report inventorying the growth of cleantech Regional Innovation Clusters (RIC) around the country. In this report, Philadelphia was ranked as the nation's fifth-most significant "cleantech cluster" (or "Regional Innovation Cluster") nationwide. More significantly, three of the five top-ranked cleantech clusters in the country are now found in the New York–Washington, D.C. corridor with Philadelphia strategically situated in the center of that corridor.

So what we have seen via these two examples on developing building efficiency is that: investment matters, collaboration roles need to be articulated in advance, and achievement of an efficiency-energy goal requires clear vision of the problem—its various shareholders and actors, as well as the very specific ways in which the industry is organized.

THE BOTTOM LINE

One simple truth of investment can summarize the entire territory we have surveyed in this chapter: no technology to reduce carbon emissions will be truly effective until it efficiently mobilizes a broad range of global capital. Even to meet national-level requirements in either China or the United States, global capital needs to be more effectively mobilized and more efficiently deployed than is currently happening. Under no realistic scenario does the Chinese government have the financial resources to meet its clean energy needs on its own. Under no realistic scenario can the U.S. market contribute to its full potential until a national framework for clean energy has been articulated.

We will now turn to considering what this bottom-line fact means for the prospect of U.S.-China clean energy cooperation over years to come.

ENDNOTES

1 For Socially Responsible Investing (SRI), an investment portfolio aligns profitability with sustainability goals.

2 See Claire M. Umali, "Solving China's Water Crisis will Yield Economic Profits," *EcoSeed*, April 27, 2010, http://www.ecoseed.org/component/resource/article/25-water-technologies/6996-solving-china%E2%80%99s-water-crisis-will-yield-economic-profits.

3 *Times Digest*, February 10, 2010, 2.

4 *Global Clean Power: A $2.3 Trillion Opportunity* (Philadelphia, PA 2010).

5 See Bill Powell, "Should China and the U.S. Swap Stimulus Packages," *TIME*, March 5, 2009; Eswar Prasad, "Assessing the G-20 Stimulus Plans; A Deeper Look," *The Brookings Institution*, March 2009, http://www.brookings.edu/articles/2009/03_g20_stimulus_prasad.aspx.

6 "The China Greentech Report 2009," *China Greentech Initiative*, p. 14, http://www.china-greentech.com/2009report.

7 This definition is from the Collins Dictionary of Business, 2006.

8 As of mid-2010, 29 states plus the District of Columbia had Renewable Portfolio Standards (RPS) in place. States also actively shape the environment for renewable energy investment through utility interconnection and net metering regulations; through rebates and grants; and through production and manufacturing incentives.

9 See the *Economist Intelligence Unit's* report as found on *Energyme.com*, June 14, 2011.

10 This according to a January 2011 report by the *21st Century Business Herald*, which interviewed a dozen of China's leading investors.

11 Richard J. Campbell, "China and the United States–A Comparison of Green Energy Programs and Policies," *Congressional Research Service Report to Congress*, June 14, 2010, p. 12.

12 Ibid., p. 13.

13 See August 18, 2011 post in the *National Journal blog*, http://energy.nationaljournal.com/2011/08/how-can-washington-green-ameri.php#2047627.

14 Jason Pontin, "Q&A: Bill Gates, The Cofounder of Microsoft Talks Energy," *Technology Review*, September/October 2010, http://www.technologyreview.com/energy/25995/?a=f.

15 She Yan-ning, "The Cutthroat Business Practices of China's Green Energy Companies," *WantChinaTimes.com*, December 20, 2010, http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20101220000041&cid=1102.

16 "Experts Warn of Overcapacity in China's Emerging Energy Industry," *AsiaPulse News*, August 17, 2010, as reprinted in *PV Times*, August 19, 2010 edition.

17 The Concorde was also once thought of as a technology which would give France and Europe the inside track to leadership in global aerospace but the economics argued differently and the investment in national prestige proved too expensive to sustain.

18 Over the 2000 to 2010 period, the United States improved its efficiency of energy use by an average of 2.5 percent annually while China registered only a 1.7 percent annual improvement.

19 Yoni Cohen, "Wall Street: We Like Energy Efficiency, Not Much Else," *Greentech Enterprise*, September 30, 2010, http://www.greentechmedia.com/articles/read/wall-street-we-like-energy-efficiency-not-much-else/.

OBSERVATIONS

During the height of the U.S.-Japan trade wars, the U.S. government hunkered down into a defensive stance of economic nationalism and created new regulations mandating increased domestic content for the ostensible purpose of protecting U.S.-made automobiles. But the complex realities of the global market made those trade regulations problematic to implement. (I know because I was at the U.S. Embassy in Tokyo at the time, charged with implementation.) Some of the models made in the United States by GM, Ford, and Chrysler contained a higher value of imported components from Japanese suppliers than did some of the finished cars being imported into the United States from Japan by Toyota, Honda, Mitsubishi, and Subaru. Many of these Japanese-made vehicles relied heavily—for everything from drive-trains to engine assemblies—on U.S. suppliers. At a practical level too, it became difficult to figure out what counted as either an American or Japanese component. What about a starter or alternator made by Nippon Denso in a U.S. plant employing U.S. workers and with parts and materials supplied mostly from the U.S.? Or what about automotive electronics designed by GM Delco in the United States but manufactured in Japan for supply to both U.S. and Japanese carmakers? I was not the only one getting headaches from this.

Eventually the "bean counting" of economic nationalism playing out at the Summit-level gave way to a more commonsensical, less government-managed reality. Japanese manufacturers began making large-scale investment in "greenfield" state-of-the-art factories, mostly in the southern United States, where political leaders tripped over each other bidding for investments.[1] Unencumbered by the legacy strictures of union wage packages and old, less efficient factories of the Detroit model, the Japanese transplants prospered and their U.S. employment expanded, turning them into formidable local political actors. Toyota even began exporting back U.S.-made vehicles to the Japanese market in some of the same auto transport ships that used to return to Japan empty. In the process, the U.S. industry—both suppliers and competitors—learned valuable lessons about

Japanese-style quality-control, inventory management, and pared down price structures.

The Japanese companies, in their turn, learned about the importance of customer service in the United States and how to build a U.S./global brand. Some companies learned the lessons better than others. Toyota established itself as a market leader in the United States and even became a sponsor of the Super Bowl without raising eyebrows. Meanwhile, Japanese automakers more hesitant to base factories in the United States were squeezed by excess capacity and the consolidation of the industry in their home market. Through it all, the U.S. consumer got a steadily improving product from both Japanese and American carmakers and both industries contributed to, and kept up with, global technological evolution.

"Co-Dependence" of U.S. and Chinese Clean Energy Markets

Recalling the auto battles which took place during the U.S.-Japan trade wars in the early 1990s should remind us of some simple lessons that also apply to U.S.-Chinese commercial engagement in clean energy.

First, global supply chains are complex. Before pointing a finger at a supposedly "foreign" product, it is increasingly essential to understand how, in fact, the product is actually made. As *Bloomberg New Energy Finance* has pointed out, "Chinese PV modules are often manufactured using U.S.-made equipment[2] while U.S. wind turbines regularly contain Chinese-made components."

Second, any effort by government to manage outcomes in the market can fall victim to narrowly conceived definitions of what that outcome should be or what it will mean for all involved parties. For instance, if the outcome is defined in terms of end-product sales of Chinese-made wind turbines and the government curtails those sales in the United States, this invariably affects the entire business ecosystem and can imperil U.S. industrial jobs in capital equipment, systems installation, and after-sales service.

Third, while some limited U.S. government intervention was clearly required to level the playing field for U.S. car-makers in Japan, all such actions

are double-edged. Almost 20 years after initial U.S. government efforts to "force" the Japanese market open, U.S. carmakers still do not enjoy the same level of market penetration for their cars in the Japanese market as in most other international markets. Some believe this is in no small part due to the fact that U.S. cars became associated in Japanese consumers' minds with an offensive, even bullying, approach to their market. For every price-competitive Chinese turbine installation which might someday be barred from the United States on political grounds, a far larger number of U.S. turbine installations in China would be made vulnerable to retaliatory risk.

Fourth and finally, a government-managed approach to solving the problem is not in line with the basic values and experience of our society. It takes us in the direction of heavy-handed practices which we justifiably criticize in our trade partner and can even give rise, especially in tough economic times, to an unhealthy "demonization" of the foreign partner.

As we consider how best to respond to competitive pressures from China, we would do well to remember some of the excesses from the U.S. response to the Japanese challenge. A congressman took a sledgehammer to a Japanese-made car on the steps of the Capitol. A group of Mexicans were attacked because, in their assailants' eyes at least, they looked to be Japanese. An ugly incident of this nature thoughtlessly directed at China would quickly be picked up as a video clip and circulated in Chinese chatrooms. Such an emotional outburst would inflame long-nursed and probably justified feelings of injury at foreign hands, provoking a virulent strain of nationalism inimical to U.S. interests.

One of the most astute observers of what is at stake in the U.S.-China clean energy contest is William Chandler, former senior associate at the Carnegie Endowment for International Peace. In "Breaking the Suicide Pact: U.S.-China Cooperation on Climate Change," he correctly points out that before considering whatever threat we imagine emanating from outside the United States, we need to get a grip on our own anxieties about U.S. energy security, our self-induced sense of helplessness resulting from four decades of policy drift:

> *Over-concern in the United States "for energy security deepens (our) dilemma (with China). U.S. congressional staff experts think energy is twice as likely to cause conflict between the two countries as human rights. Mainstream Americans fear that China is gobbling up oil and driving up the price of gasoline. The Chinese fear American control of Middle East oil and shipping lanes to China."*[3]

Meanwhile, Americans need also to be careful about slipping past righteousness into an indefensible position. The carbon emissions trends are stark and worrying but they are not the basic issue at play. That issue is the desire in China and elsewhere in the developing world to enjoy a lifestyle comparable to what they have witnessed North American and European societies enjoying for decades, even centuries. An overly focused, hectoring stance about reducing carbon emissions can easily be heard in China as an attempt to deprive Chinese of the lifestyle taken for granted by the hectorer. The argument that remote villages should not replace hand-carried water buckets with electrical pumps is not a winning one, especially if the person making the argument has traveled from the opposite side of the world on airplane fuel.

Hans Rolsing has captured the trajectory of human development by national groups over the past two centuries in a visually dazzling four-minute video.[4] Even the poorest parts of China will be tracing that arc towards longer life and greater prosperity. It does not strike me as wise to suggest that a village in Sichuan aiming to replace water buckets with an electrical pump should not do so to spare the air at ski resorts in the West.

We need to be working with the Chinese, earnestly and creatively, but as full partners. Their lifestyle aspirations need to be met but we must accomplish this through a new 21st century low-carbon lifestyle that we, too, must adopt. China and India can be among the lead innovators or not, but they will inevitably be among the lead recipients of this trend, given their populations. Alternatives simply will not work. It will not work to tell Chinese they can not aspire to a lifestyle much of the world already enjoys. It will

not work for the Chinese to simply mimic the carbon-intensive lifestyle of the 20th century. As Chandler puts it, "what if the Chinese used energy like Americans? Global energy use would double and five more Saudi Arabias would be needed just to meet oil demand. China itself would produce six times as much coal as it does today."

Clearly, a different approach is needed. The United States and China, along with the EU and India, will have to find it together. Most of the "hardware" applications for future economic growth are already shifting to emerging Asia but the "software" innovation to power this "hardware" can continue to be better pioneered in the advanced economies of the West[5] if they move smartly.

Complementary Strengths at Global Scale

The only way the United States and China can realistically uncover that future is by focusing on the individual and distinctive strengths each brings to the equation. Tempting though it might be for each side to simply bemoan the other's inability to mimic the first's virtues, commonsense and the whole thrust of our examination to this point show this to be a counterproductive pipe dream. Truth does not have a national flag on the t-shirt it wears. Both the United States and China face an energy challenge unlike any either has previously faced. We will need to forge a joint effort that draws fully from the strengths available—and those strengths exist separately and uniquely in both countries. At the same time, we need to recognize and manage our respective societal weaknesses, not play them out on the global stage. The foundation for our partnership must necessarily be respect—acknowledged respect for the real strengths which the partner brings but, equally important, quiet recognition and "self-respect" for the values and experiences which we bring as partners to the endeavor. China and the United States dominate the consumption of world energy, it should not be surprising that they need to work together to resolve the critical challenges that result.

The preceding chapters have hopefully sketched out the outlines of complementary skill sets that the United States and China possess in addressing this challenge. The fastest way forward to effective partnership is mutual acceptance of the potential for a "partnership division of labor" that will bring those skill sets together. Scarce resources and prospective global climate change demand both sides' recognition of this fact. Cooperation and collaboration between the United States and China are the "sine qua non" prerequisite of any meaningful response to efficiently managing energy resources and effectively managing global warming. Of course, achieving global scale for this partnership will require the rallying of political, technological, and financial resources in both countries to better support what each does best. This can only be achieved if it is based on mutual, frank, and realistic appraisal of the strengths and weaknesses of each system and then a yoking together of the strengths of each. There is no other way to scale a practical solution to the actual size of the global climate change challenge and, hence, no other combination of nations that can forge such a platform.

So what are these complementary skill sets? For the United States, a key skill is our time honored ability to innovate[6] and collaborate in re-inventing ourselves and working with anyone who shares our vision to build a better future. These skills created a post-World War II international economic system that served the world well over the past 65 years, even if it may need modifications now. These are, as President Obama pointed out in his Penn State University speech, the skills which put "Eagle I" on the moon and spawned the entirely new industries of commercial aerospace, advanced electronics, and new materials. These are the skills which developed the Internet and are now pioneering a new revolution in social media technologies, one that we have just seen change the foundation of nation states in the Middle East and elsewhere.

For China, the skill-set surely includes the mastery of scale and speed which China Inc. has demonstrated over the past 30 years. In scale, China's annual migration each year involves more people than the entire population

of the Netherlands. The amount of generating capacity which China adds to its grid each year exceeds the total existing installed capacity in all of the United Kingdom. In speed, China has built global class megacities out of rice fields and fishing villages in just a 30-year period. It has built a wind power industry to match that of the rest of the world in less than half the time the world industry has taken to develop.

Over the past 30 years, China has leveraged its manufacturing scale and speed to offer the world the "China price" for an outpouring of manufactured goods and other "stuff"[7] destined for export markets. Post-GFC, those markets no longer want so much "stuff" and, in any case, there is not enough money in consumers' pockets, or credit available, to pay for it. China's leadership is therefore under increasing pressure to redirect the juggernaut it has built away from export markets to more directly support the needs of its own society. In managing this transformation, China has an opportunity to nudge the trajectory of scale and speed it has introduced to the outside world. Rather than continuing the narrow, "neo-mercantilist" objectives it has favored in the first stage, China has a chance to put the scale and speed of its market to broader use, in partnership with the United States, to help build a more sustainable future for everyone.

More concretely, we have seen working models in multiple industry sectors of what this partnership between U.S. collaborative innovation and Chinese scale and speed looks like. I will call it the "prototype to production" model of partnership:[8] It marries the strength of the U.S. system in generating new ideas, new paradigms, and new breakthroughs with the proven ability of China to bring ideas to scale fast. This can create a "virtuous cycle" of innovation and deployment at commercial scale taking place at a global level to accelerate clean energy breakthroughs.

- In clean coal, the deployment of first-generation Carbon Capture and Sequestration (CCS) facilities is already taking place faster and more extensively than could ever be contemplated in the United States. However, that effort is taking place with American researchers, American companies, and American investors as innovation leaders;

- In energy efficient buildings, we have taken a close look at a collaboration involving Lawrence Berkeley Lab, Tsinghua University, and eventually the national-level GPIC Energy Innovation Hub in Philadelphia. This collaboration promises to address, through those three institutions, the 16 percent of global carbon emissions that trace back to buildings in either the United States or China.

- In the nuclear energy field, China National Nuclear Corporation has partnered with Westinghouse to build a string of third-generation nuclear reactors to power China's coastal cities. As we have seen, other strategic opportunities are taking hold between U.S. industry's advanced capabilities and China's galloping domestic needs;

- In smart grids, General Electric has undertaken strategic cooperation with China's State Grid Corporation to jointly develop smart grid standards for China and, potentially, other emerging markets;

- In solar, U.S. technology and capital are at the forefront of both a landmark solar thermal project as well as in bringing advanced photovoltaic technology to the world's largest solar power plant in Ordos, Inner Mongolia.

Even in the highly competitive wind power sector, the opportunity exists for U.S. and Chinese companies to learn from one another, both competitively and cooperatively, much as the U.S. and Japanese auto industries learned from each other and boosted each other's eventual global competitiveness two decades earlier.

"Sub-National Linkages" and Clusters: Where the Action Is

The way forward is cooperation around clean energy innovation.

By looking at all the various sectors of cooperation, we know what the vehicle of cooperation to take us down this road looks like. It will be steered by U.S. innovation but powered by the twin engines of Chinese scale and speed.

A roadmap is at hand but government can only do so much at the national level. The two national governments, with substantial intellectual assistance from Michael Porter and the Brookings Institution, have created the framework for this model. The U.S.-China Clean Energy Research Center (CERC) program and related initiatives will help further draw the roadmap during periodic meetings of the Strategic and Economic Dialogue.

The question then is who goes down the road? The answer, increasingly, is innovative cluster regions, states, cities, public/private consortia, universities and companies. These are the so-called "sub-national" linkages which are moving U.S.-China clean energy cooperation forward and doing the real work of building partnership around a 21st century energy economy.

Three points in closing about this:

Energy innovation does not stop at the border. Any city, state, or region looking to position its economy for future growth tied to 21st century energy innovation, needs to partner effectively within the region, and with other clusters—nationally and internationally. Local, national, and international "connectedness" is what gives life to the clean energy clusters described in Brookings' "Sizing the Clean Economy" report released in July 2011.

Second, for partnership to take root particularly with China, it is basic courtesy (and shrewd business[9]) to show an organizational face which Chinese decision-makers recognize and can feel comfortable with. In China, there are more diffuse boundaries between government, academia, and industry which allow for greater pooling of resources among commercial, financial, and technical domains. Innovation-focused groups in the United States need to mirror this in the form of purpose-driven public/private partnerships to show the Chinese side that they effectively pool domain knowledge as well. The China Partnership of Greater Philadelphia[10] is one such organization.

Third, when the organizational basis for effective partnership is in place, it needs to be effectively leveraged. There are important resources to provide this leverage but they need to be identified, matched, and effectively

implemented. One such resource is the EcoPartnership program of recognition which gives federally-backed recognition, through the Strategic and Economic Dialogue, to outstanding examples of U.S.-China partnership for environmental sustainability. This can be awarded at the company, city, state, or "cluster"/region level.

It is perhaps fitting to end these observations by mentioning one of the most significant events in the U.S.-China bilateral process to take place recently—the "China-U.S. Governors Forum in Salt Lake City" in mid-July 2011. It is perhaps not entirely coincidental that this meeting took place in Utah, the home state of Jon M. Huntsman, Jr., U.S. Ambassador to China from 2009–2011. Utah is in a good position to appreciate the growing importance of these linkages. In the Chinese press, the headline on the report about this meeting read simply, "Leaders Vow to Enhance Sino-U.S. Relations at the Sub-National Level."

CONCLUSION

While everything seen in the U.S.-China relationship influences and backdrops the bilateral dialogue, we have seen from our examination of this one area—clean energy—that the doorbell has rung for a new era of demanding competition. This competition can hone strengths but can also erode goodwill. It will take realism and principled action from both countries to maintain positive and sustained cooperation in the future. There are significant drags holding us each back on this path.

As obvious as it is that China pays attention and "games out" the United States reasonably well, our more public and frenzied political decision-making process may hinder deeper and more forward-looking planning. This handicaps the United States.

On the other hand, China is finding itself increasingly on the world's center-stage without having had to pay the costs of leading a fractious world community. That will change and is likely to complicate China's efforts to continue its trajectory of pursuing wealth while suppressing serious

questioning. This will handicap China going forward.

This book has looked in detail at this one area of U.S.-China competition and collaboration for the insights it can offer about our bilateral relationship in the future. The United States is driven by political forces that are messy and can defeat the best and smartest intentions. That said, the United States is experienced and know the script for global leadership. China has acted with extraordinary will power through planning and its powerful control of society to bring it to the top rank, but the collective top-down system that has brought it wealth is unlikely to shake free from the growing pressures caused by: demographic and urbanization pressures, by demands from its citizenry for more transparency and participation in the political process, and by insistence from international partners for a more balanced and sustainable development model.

By intelligently and realistically engaging on the clean energy issue, we each have a chance to re-define ourselves and our relationship, one that will be the pivotal axis on which the world dances for at least the next century. This goal is worth attaining but will be difficult to achieve. Our success or failure may, in the end, frame the mix of competition/conflict versus cooperation/goodwill which we hand down to our grandchildren and grandchildren's grandchildren. It will take smart politics in both countries, full recognition of the challenge, and some luck. Most of all, it will require a discerning eye for the strengths we bring as individual partners as well as commitment to the need for partnership to address the challenge. Realistically, there is no path to a sustainable future without sustained and clear-eyed cooperation between the United States and China.

ENDNOTES

1 The clean energy delegation accompanying President Hu during his state visit to Washington, D.C. in January 2011 examined the limited options for deploying Chinese capital in the United States to further advance U.S.-China clean energy cooperation. Unlike Toyota and the Japanese auto transplants in the 1990s, the Chinese currently have neither a sufficient technology advantage nor the global management experience to manage a high-profile "green-field" investment into the United States. While they have been quietly acquiring distressed manufacturing assets in Detroit and real estate assets in New York, there is a limit to how much acquisition activity they can engage in without attracting negative publicity. Fund participation does remain a way of "getting their feet wet" in the U.S. market but it does not confer management control.

2 AMD now has nearly 2,000 employees in China as well as its second-largest research center globally.

3 William Chandler, "Breaking the Suicide Pact: U.S.-China Cooperation on Climate Change," *Carnegie Endowment for International Peace*, Policy Brief No. 57, March 2007.

4 See http://www.youtube.com/watch?v=jbkSRLYSojo.

5 In 2000, Tom Friedman suggested in *The Lexus and the Olive Tree: Understanding Globalization* that Asia had over the post-war period effectively "downloaded" the "software" which had underpinned several centuries of economic success in the West. It might be useful if, in the United States, we could matter-of-factly recognize this as a mark of success in a fast-changing world and focus on rolling out the next "generation" of improved "software."

6 This is precisely why the United States needs to vigorously continue to counter China's attempts to coopt intellectual property through its "indigenous innovation policy" and other means. Intellectual property and innovation are the U.S. side's principal contribution to the partnership; these contributions need to be duly recognized by China and safeguarded for the partnership to thrive.

7 See http://www.storyofstuff.com/.

8 "Pro to Pro" or "P2P."

9 The most disconcerting thing for a potential Chinese investor is being told he or she will need to talk with different government offices at the federal, state, and local level for information on tax treatment, to still another office for information on locating a facility at a particular site, and to who knows who for information on school options. This is not how foreign investors are treated in China where a "one-stop-shop" answers all of the investor's questions. Areas which are serious about partnering with China in innovation need to furnish, again through public/private partnership, a welcoming service which provides a straight path, rather than a labyrinth, for all these questions and more.

10 For more information go to www.chinaphilly.org.