A CHINA ENVIRONMENTAL HEALTH REASERCH BRIEF

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Wising Up: Smart Grid as New Opening for U.S. China Energy Cooperation

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BROWN-OUT BLUES

With an average GDP rate of 10 percent for the past thirty years, China's economic boom has brought millions out of poverty and fueled a rate of urbanization that is faster than any country in human history. Between 1980 and 2008, China's urbanization rate rose from 20 to 44.9 percent, with the current urban population reaching slightly over 600 million.[1] Strikingly, in an effort to address growing poverty in rural areas the Chinese government aims to promote urbanization of nearly 15 million each year until at least 2030, at which time 60 percent of China's population will be urbanites.[2] Maintaining a stable, safe, efficient, and clean national power grid for China's rapid economic and urbanization growth is truly a Herculean task for the Chinese government and power utility companies.

China's grid has not been able to keep up with the country's growth and it faces particular challenges in times of extreme weather, such as during the Chinese New Year holidays in early 2008, when more than a dozen provinces in southeast and central China were hit by the most severe snowstorm in the last 50 years.[3] The power grid throughout the region was severely disrupted, both by downed lines and delayed coal deliveries. According to the Ministry of Civil Affairs, more than 30 million people were affected by the snow-triggered power shortage.[4] This outage highlighted the low self-recovery and regional coordination capacity of China's outdated power grid. However, large-scale power outages are not simply products of extreme weather or natural disasters in China. In recent years brownouts and blackouts are regular occurrences in China's developed east coast cities, especially during peak hours in the summer. The reason for this situation is threefold; low generation capacity, shortages of coal, and the incapability of the transmission grid to deliver electricity to meet demand.[5] In the first half of 2004 alone, 24 out of China's 31 provinces and municipalities suffered from blackouts due to insufficient power supply. The economic cost of these blackouts equaled nearly 1 percent of China's annual GDP growth that year.[6] The overall situation has not improved significantly since then.[7]

According to a joint publication by the International Energy Agency (IEA) and Organization for Economic Co-operation and Development (OECD), China's power sector is struggling with issues of reliability and its electric power supply regularly fluctuates between periods of highly disruptive supply shortage and inefficient over-capacity.[8] An increasingly typical blackout occurred in a summer evening in 2006, when a number of major cities in Henan Province experienced the most severe and wide-spread electric outage in the province's history. The cost was enormous: all traffic hubs experienced chaos with passengers at railway and bus stations and panic also spread among people in shopping malls, restaurants, and movie theaters that were hit by a total blackout. Manufacturers in affected areas reported huge losses as the power outage forced them to cease operation and they subsequently had to pay millions in penalties for delay in product delivery to customers overseas. The provincial government attributed cause to be the low capacity of the power grid, which failed to deliver electricity from western China into Henan.[9]

Powered By a Dirty King

Coal is king in China, supplying nearly 80% of the country's electricity.[10] Thus, inefficiencies in power generation, transmission, and consumption not only waste energy and create economic losses, but also increase in pollution from coal-fired power plants.[11] Air pollution is already one of the leading causes of death in China—the World Bank estimates 750,000 Chinese die from respiratory illnesses each year from air and water pollution.[12]

To address the pollution problems associated with coal-burning, the Chinese government has pushed policies that encourage energy conservation and cleaner energy production in China's industrial and municipal sectors. Moreover, power plants are facing stricter emission regulations and older plants are closed as ultra-modern ones are being built. Reforms and targets to "green" China's ever-expanding power grid sector are still considerable, ranging from more R&D and investment into ultra-fast and more efficient power lines and renewable energy technologies, to building stronger monitoring institutions and better integrating wind, solar, and hydro sources of energy into the main grids.[13]

OVERCOMING GRIDLOCK IN CHINA

The obsolescence and lack of regional interconnectivity and coordination[14] of China's existing power grid system represent major obstacles for the country's targeted urbanization and industrialization, as well as growing priorities to address the serious urban air pollution. Exacerbating the pollution is the fact that much electricity is lost during power transmission and consumption, as well as losses due to inefficient and badly coordinated distribution.

One of the key weaknesses of China's existing power grid is the low energy efficiency associated with poor control of generation, distribution and transmission, along with a lack of effective demand management measures. The loss of electricity through transmission and distribution alone in China reaches 8 percent of total generation, which is almost 6 percent higher than the level in developed countries, according to Chu Ching-wu, a leading electric power expert from Hong Kong.[15] This wastage in transmission and distribution is exacerbated by a set of poorly monitored consumption behaviors by industries and consumers such as the use of low-efficiency lighting and machinery products. At present, China's overall energy intensity is four times that of the United States and nine times of Japan.[16] To make up the lost energy, Chinese power plants must burn even more coal-burning that further worsens the country's already unacceptable air quality.

Realizing the importance of energy efficiency, the Chinese government is taking action. In its Eleventh Five-Year Plan published in early 2006, the central government of China set out general guidelines and targets to improve energy efficiency and increase investments in clean energy technologies.[17] This plan has sparked new policies and regulations to encourage greater supply and demand of clean and renewable energy such as solar, wind and nuclear. Some of the central government's rather ambitious goals include:[18]

- Reduction of CO_2 by 1.5 billion tons by 2010;
- 15 percent of the nationwide energy supplies from wind, biomass, solar, and small hydropower by 2020;
- In a breakdown of the renewable energy plan, China is pursuing a solar power capacity of 2 gigawatts by 2011;[19] a nuclear power capacity of 11 gigawatts by 2020[20]; and a wind power capacity of 100 gigawatts by the same year.[21]
- Decrease in national energy intensity by 20 percent between 2006 and 2010.[22]

Some Chinese corporations have gone beyond government energy efficiency and clean energy requirements for they have seen huge opportunities for profits from being green. China Mobile, the world's largest wireless operator with 420 million subscribers, has set a target of reducing its energy intensity by 40 percent by 2010, which is more than double of the national target.[23] The mobile service giant is joined by a number of other leading Chinese corporations including Lenovo, Broad Air Conditioning and Suntech in being partners with the Climate Group, a coalition of governments and the world's most influential businesses with the goal of tackling climate change.[24]

Problems Feeding Into the Grid

All the ambitious public and private sector initiatives pushing energy efficiency, renewables, and clean technologies cannot be realized without a compatible infrastructure which must have full capacity to accommodate variations that are spread all over the system. In the power sector, the desired infrastructure would be an advanced electric grid that could deal with the intermittent nature of generation of electricity by clean energy. At present, China's grid does not have such capacity. Take wind power as an example, in 2008 all major Chinese wind power developers reported cases in which they were denied access to the grid due to various technical issues as well as lack of experience of the State Grid Corporation of China (SGCC) in managing high-voltage transmission.[25] The biggest challenge, therefore, is not associated with finding or producing renewable energy; it is about how, with reasonable costs, to transport and distribute the power derived from renewable energy to meet the vast demand of the country's booming economy with high consistency and reliability.

Fortunately, the Chinese government has realized the magnitude of relevant issues it faces and is already taking actions. SGCC has determined to build a "nationally unified" modern grid[26] that has enhanced capacity in dealing with issues ranging from demand management and variation in supply, and is undertaking research and development of smart grid technology.

SMART GRID PRIMER

Before delving deeper into China's smart grid plans and potential opportunities for Sino-U.S. cooperation some clarification of the technology is needed. A "smart grid" is not a single entity, rather an umbrella term that covers modernization of both the transmission and distribution grids.[27] The modernization of the power grid is basically the process of converging various branches of information technology (IT) with power delivery technology in order to achieve reliability, efficiency and sustainability of the grid system.[28] It is important to note that most of the core technologies and components that compose the smart grid already exist and are commonly used by industries and consumers, such as smart meters, phasor measurement units (PMU),[29] Advanced Metering Infrastructure (AMI),[30] and so on.[31] This means the development of smart grid does not require costly and sophisticated technologies, rather demands better communication, coordination, and incentives for consumers, power suppliers, and government agencies.[32] Such a modernized grid should be able to achieve a set of broader energy, environmental, and economic goals, some of which include:

- **Protection From Huge Brownouts.** Although the smart grid has an inherently high interconnectivity among different regions, when a local outrage occurs, the grid has the ability to immediately isolate the incident so damage remains at the minimum level;[33]
- **Greater Energy Supply.** Because the smart grid has the ability to integrate power generation from renewable sources, it allows for two-way flow of electricity—from coal-fired power plant utilities to consumers and from clean power generation at end-user level (such as household solar pads) that can send excessive electricity back to the grid and have it transmitted to other sources of demand with high efficiency.[34]
- **Environmental Protection.** Smart grids can promote the co-benefits of lower CO_2 emissions and better air quality through: (1) less wasted coal through energy loss in

transmission and distribution and, (2) better integration of intermittent renewable energies such as wind, solar and biomass.

- **Consumer Savings and Conservation.** Smart grids can help consumers obtain massive savings as they are well informed of real-time market energy costs and can thus make better consumption decisions; and,
- **Green Jobs.** Smart grid can help promote demand in the job market in engineering, construction, computer, and component manufacturing fields.

STEPS TO SMARTER POWER GRIDS IN THE UNITED STATES AND CHINA

Actions in the United States

Recognizing the significance of energy efficiency and the indispensable role of smart grid, the Obama Administration and Congress have offered tremendous support to a nationwide campaign for smart grid development. Early in 2009, the Senate majority leader Harry Reid announced that the Senate is looking ahead with a "smart grid bill" in order to "modernize the country's electricity infrastructure."[35] Almost simultaneously, the White House officially added funding for smart grid to the stimulus plan.[36] As the person who oversees the planning of such energy infrastructure initiatives, Secretary of Energy Steven Chu announced that $3.9 billion would be invested in work related to smart grid development.[37] Long before this happened, the Department of Energy (DoE) had already completed numerous research activities on possible ways to develop a nationwide smart grid; it has also put out a series of publications to educate the public and gain support.[38]

Momentum Building

In July 2009 the U.S. DoE made numerous announcements on how the United States will promote smart grid development domestically and abroad as a means to promote energy efficiency and security. Most notable was in July 2009, when U.S. Energy Secretary Steven Chu, Chinese Minister of Science & Technology Wan Gang and Chinese National Energy Administrator Zhang Guobao announced plans to develop a U.S.-China Clean Energy Research Center. This center would aim to facilitate joint research and development on clean energy by teams of scientists and engineers from the two countries. The headquarters for both countries is still being discussed, but both countries have pledged $15 million to support initial activities. The center will formal open at the end of 2009 and one priority area for joint research and development is smart grid[39]

Once back in the United States, Energy Secretary Steven Chu announced that 8 smart grid demonstration projects have been selected to be the recipients of a total of $47 million grant from the American Recovery and Reinvestment Act (ARRA).[40] The momentum for smart grid development in the United States was high throughout July 2009:

• The Federal Energy Regulatory Commission (FERC) issued a Smart Grid Policy Statement on 16 July 2009 that sets priorities for work on development of standards crucial to a reliable and smart grid—such as ensuring the cyber-security of the grid; promoting two-way communications among operators, utilities, service providers and consumers; as well as coordination in integrating emerging technologies into the power system.[41]

• The Committee on Science and Technology in the House of Representatives held its first ever hearing focused exclusively on smart grid on 23 July 2009. During this session, a panel consisting of top smart grid experts offered their thoughts on the prospect of smart grid development in the United States, and the general response was very positive and encouraging.[42]

• DoE confirmed a new provision in late July of up to $30 billion in loan guarantees for renewable energy projects including ones related to smart grid. [43]

- DoE also announced an additional $750 million for major improvement works on the nation's power transmission system.[44] Five projects for developing solar energy grid integration systems (SEGIS) were awarded up to $11.8 million as part of the effort to raise the nation's power grid reliability.[45]

U.S. Corporations on the Move

Sensing the huge business opportunities embedded in smart grid, U.S. corporations—sometimes in partnership with local governments—have acted earlier and even faster than the federal government. Xcel, a leading public utility company, started the world's first citywide smart grid pilot project in early 2008 in Boulder, Colorado.[46] According to the timeline, the project has entered its final benefit evaluation period and steady progress has been reported.[47] Having observed the success and business potential of Boulder, other US energy and utility companies were following Xcel's steps. In early August this year, Consolidated Edison, one of the largest investor-owned energy companies nationwide, announced a $6 million smart grid pilot project in Northern Queens area in New York City.[48] This project will see 1500-1800 households have smart meters and other advanced utility devices installed. In the city of Miami, Cisco, the giant in communications technology and service market are currently partnering with GE and some other energy organizations to work on the "most comprehensive smart gird deployment in the US".[49] This project, titled Energy Smart Miami, will install more than 1 million smart meters to every home and most businesses in Miami-Dade County, and is aimed to create approximately 900 green jobs. It is also expected to serve as the cornerstone of smart grid development in the United States.[50]

While investments in smart grid projects are increasing, it merits mention that most of he successful cases have been small- to medium-scale pilot projects and it remains unknown whether such initiatives will show the same benefits nationwide with a much higher level of complexity. Another complicating factor in expansion is the growing conflicts that could arise between states and the federal government over the cost sharing in the construction and management of cross-country transmission lines.[51] Additionally, the role public utilities would play under a national smart grid system remains unclear. The utilities' core interest is directly associated with power consumption at the end user level and without appropriate policy provisions, the smart grid could simply reduce their revenue by increasing the level of energy conservation and decreasing the average energy usage.[52]

THE CHINESE PERSPECTIVE ON SMART GRID

Like the U.S. government, China's central leadership has prioritized the development of a highly intelligent nationwide power grid. In June 2009, the State Grid Corporation of China (SGCC), the state-owned and the largest electric power transmission and distribution company in the nation, announced that it was planning to build a nationwide "strong & smart" grid by 2020.[53] While it is essentially only a blueprint of smart grid development, SGCC's plans have certain distinctions from the direction being taken in the United States on smart grid.

First, China emphasizes the importance of the proposed grid being "strong" as a foundation for further development towards grid intelligence.[54] This is to say that China expects the grid to be reliable, resilient and able to transmit large amounts of electricity across the country; the core technology in this regard would be ultra-high voltage transmission. In contrast, the U.S. side, represented by major IT service providers such as Cisco, GE and IBM are more focused on the "smart" aspect of the grid which requires advanced technology on super-conductor and other cyber-tech intensive measures.[55] Take Cisco as an example, its vision of smart grid development is the building of a set of secure and reliable IP networks that connect utilities, power suppliers, and customers and facilitate the process of information gathering.[56]

Second, China's vision of the modernized grid is highly centralized in terms of generation while the U.S. approach has a higher dependence on distributional generation; while being a nationally

interconnected network, the grid in the United States will more often operate at the local level as many independent, "micro" grids.[57]

Different circumstances also bring about different institutions and different opportunities, and in the case of smart grid, both have presented advantages for China. First, as Yining Qin, a scientist from China's prestigious Huaneng Group and currently a visiting scholar at Lawrence Berkeley National Laboratory explained, most policy initiatives in China are government mandated; SGCC proposed the strong and smart grid as a nationwide plan, which means at least at the early stages there will likely be very few obstacles in terms of implementation at the local level. Qin noted that since the central government has given its approval for the nationwide smart grid plan, funding would not initially be an issue either. In fact, the Chinese government has shown considerably commitment by targeting approximately 200 billion Yuan ($30 billion) over the next eleven years on smart grid development.[58] Like the United States, however, after the initial construction, as issues of local and center cost sharing of construction and maintenance emerge, there could be difficulties.

Second, according to Qin, the growing demand in China's power sector indicates that unlike its western industrialized counterparts that need to bear the cost of integrating the smart grid with their existing, traditional grids which were built decades ago, China is starting from scratch in its vast rural areas where basic power infrastructure is lacking. Moreover, China's research into power grid technology has been pushed by the demands of the country's rapidly growing economy and in some areas China's relevant technology is more advanced than what United States currently possesses.[59] The West-East Electricity Transfer Project, which is also projected to be in operation by 2020, was proposed to address the lack of power infrastructure in western China where resources are abundant.[60] Once completed, the three cross-country transmission corridors will help match demand in the developed east with supply in the underdeveloped west. This presents an excellent opportunity for China to lay the foundation of smart grid by planning simultaneously.[61]

Third, there are questions in the United States and China about whether each country has sufficient skilled workers to support the daily operation of smart grid.[62] While China does produce four times as many engineering specialists as the United States does,[63] many will most likely need a few years of training after graduating to reach the technical levels needed for smart grid work.[64]

CHALLENGES FOR CHINA

Although China is making solid progresses on R&D of smart grid, it also faces a number of challenges on both technical and institutional levels. The biggest challenge is the lack of industrial standard which serves as a guidance for manufacturers of smart grid components, such as smart meter, sensor, and electric vehicle interface. As a matter of fact, because smart grid is a relatively new and innovative concept, so far there has been no industrial standard that works exclusively for smart grid anywhere in the world. The U.S. approach to address this issue has been to select a pool of existing standards in relevant industries that are suitable to be tailored for smart grid. As part of the smart grid initiative, with technological support from the National Institute of Standards and Technology (NIST), the Obama Administration has recently issued a set of 16 existing standards as a guideline for members in the industry.[65]

With regard to the situation in China, there have been different views among business and non-profit professionals. According to a John McDonald, general manager for GE Energy T&D, while the SGCC is yet to develop its own standards, it has not come to fully embrace the idea of transferring relevant international standards from institutions such as IEEE to China's own circumstances. His impression is that China is not very keen on using standards that are not written in China.[66] Nevertheless, there is an alternative view from the non-profit sector that it is the unhealthy nature of utility market in China that led to the slow progress of standard writing; the fact that utility market in

China is fully controlled by the state means that incentives are lacking which significantly limits the scope of participation.[67]

The Chinese government and its power utility companies are also confronted by the lack of R&D on the demand side. Although end-user equipment such as metering device in the more developed eastern China are generally newer and more advanced than those currently deployed in the United States,[68] Chinese power utilities face difficulties in gathering data on demand so the dynamics between supply and demand cannot be managed efficiently. Furthermore, end-user equipments in the much impoverished western China are way behind both in terms of technology and quantity. This suggests that if China intends to develop a nationwide smart grid, its focus on ultra-voltage transmission lines must be accompanied by a massive renovation of end-user equipments and more input on research of demand information.

Another issue of smart grid, which is not necessarily only related to China, is that because it relies so heavily on cyber-technology, it has a higher vulnerability to cyber attack or mechanical Internet failure than the more traditional grid. Some experts claim that by breaking into the system, hackers could easily manipulate demand for power and cause major system turbulence.[69] Although it is claimed that technologies for grid protection do exist,[70] the industry has not come up with any clear-cut cyber security standard for the grid.[71]

OPPORTUNITIES FOR US-CHINA COOPERATION ON SMART GRID

Cooperation on climate change and environmental issues could become a major driving force in forming the new era of U.S.-China bilateral relations. Such cooperation not only provides an opportunity for the world's two largest energy consumers to improve regional and global air quality through cleaner and more energy efficient development, but also such collaboration helps build some goodwill in what is often a strained relationship. The upcoming meeting of the U.S. and Chinese presidents will likely include dialogue on energy and climate issues, underscoring how both nations are prioritizing such bilateral cooperation. During a June 2009 Senate Committee on Foreign Relations hearing on the opportunities for U.S.-China cooperation on climate change, most of the testimony and discussion was very positive, with many speakers commenting on how despite the challenge of massive urbanization, China has already been very progressive in working to promote energy efficiency and clean energy development.[72] The atmosphere at this hearing was a marked departure from the long-held view among many in Congress that the U.S. could only cooperate with China if the Chinese government committed to GHG caps.

The improved political atmosphere provides excellent opportunities for enhancing bilateral energy cooperation and collaboration and exchange on smart grid development could be mutually beneficial. This bilateral cooperation can build on years of U.S. NGO, foundation, and national laboratory work in the energy sector in China—organizations such as Natural Resource Defense Council, Energy Foundation, EDF, and Lawrence Berkeley National Laboratory. Notably, U.S. corporations are already on the move in China on smart grid. For example, business solutions and IT services providers such as GE, IBM, and Cisco have all reached out to China to offer their technical expertise on distribution issues, for unlike the U.S., Chinese planners and electric utilities are focusing on ultra-high voltage power generation and transmission.

Brainstorming Areas for Smart Grid Cooperation

Between the United States and China, current priorities for developing a modernized grid do differ, with the United States focuses more on the "smart" and China on the "strong" grid. Moreover, the United States is faced with the challenge of upgrading an old, highly decentralized grid system and China is embarking on creating a new centralized power grid. Despite these differences there are opportunities for collaboration for both countries. The newly established U.S. China Clean Technology Center clearly represents a platform for smart grid technology research, but the two

countries can cooperate on broader issues of standard writing, training, and education. For example, while China is focused on highly centralized projects to build high power lines, the country has already begun a phase of pilot projects in Chinese cities that are experimenting with micro grids, not unlike the pilots in the United States in Boulder, New York, and Miami. Additionally, public utility companies in both countries will have to drastically change the way they work, particularly on how they interact with customers. Thus, exchanges and joint learning among power and utility companies and regulators in both countries could help both sides learn faster.

The ideal platform for such exchanges and joint projects would most likely be cooperation between U.S. and Chinese cities or better yet provinces and states. Such local-to-local partnerships could promote information exchange and cooperation that could not only promote joint learning on smart grid, but also help to create opportunities for more sub-national low-carbon development in other clean or energy efficient technologies.

One current example of training that highlights the potential of local-to-local education and public-private partnerships on smart grid is the work being done by the NGO Joint US-China Cooperation on Clean Energy (JUCCCE). JUCCCE has been active in promoting cooperation on smart grid between the U.S. in China, such as undertaking training Chinese mayors and other officials in an to attempt familiarize them with the concept and incorporate it in their local development agenda.[73]

FINAL SMART THOUGHTS

With all the distinctive benefits that it envisions, smart grid holds the promise that the power sector can go "green" by not simply reducing the use of dirty power generation methods but instead become a system that can take more aggressive measures to lower greenhouse gas emissions through efficient integration of renewable energy sources. Smart grids that focus on improving demand-side management for energy and promoting renewable energy could be a transformational force that redefines the way people view energy generation, transmission and consumption, in that such grids would encourage active engagement by the broader society, not just power sector specialists.

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considered one of the most important measuring devices in the future of power systems. Source: http://en.wikipedia.org/wiki/Phasor_measurement_unit#cite_note-0

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