A CHINA ENVIRONMENTAL HEALTH PROJECT RESEARCH BRIEF

This research brief was produced as part of the China Environment Forum's partnership with Western Kentucky University on the USAID-supported China Environmental Health Project

Boomtown Energy Drain: Promoting Energy Efficiency in China's Buildings

By Alan Campana

In the international effort to curb global air pollution emissions that lead to climate change, acidification of the oceans, and increased cancer rates, Chinese energy consumption stands out as a major challenge. Sustainable energy production will play a role in future greenhouse gas reduction, but progress in this arena is slow due to path dependence on fossil fuel technology. China is and almost certainly will remain reliant on fossil fuel based energy production for the foreseeable future. Thus, reducing how much energy is consumed will have a positive impact, and significant reductions can be attained in a relatively short time frame through improving energy efficiency.

A FOUNDATION TO BUILD ON

A substantial potential to increase energy efficiency is manifest in Chinese buildings. It is estimated that currently, the entire lifecycle of commercial and residential buildings, from materials manufacturing and construction to use and final demolition, represents 45 percent of China's total energy use,[1] and building final energy use accounts for approximately 25 percent of China's overall energy consumption.[2] These energy consumption rates are expected to increase as a result of the continuing construction boom. The equivalent of a new Shanghai is erected in China each year,[3] and the Chinese government plans to relocate 400 million citizens to new urban centers by 2030.[4] Housing and employment of the future urban population virtually guarantees continued rapid construction, leading to increased building energy consumption. Moreover, Chinese buildings in general are rather energy inefficient. The high demand for buildings has led many in the construction industry to build as cheaply and quickly as possible.[5] The consequences are that a vast majority of buildings lack even basic energy saving features such as insulation weather stripping. These buildings are essentially bleeding away energy through gaping wounds. China's buildings sector energy consumption resulted in 1.1 gigatons of green house gas emissions in 2005, and it is projected that under current policy, this figure will rise to 3.2 gigatons by 2030. However, the same study estimated that 2030 emissions could be reduced to 1.6 gigatons if China fully implements practical green technologies.[6]

This scenario presents both challenge and an opportunity. China must meet its burgeoning energy and infrastructure demands, but it has the opportunity to use modern, clean materials and technologies to lay a more sustainable infrastructure and achieve a cleaner development. China's concerns over energy security and future access to affordable supplies of fuels in particular have motivated a national drive to improve energy efficiency, and China is welcoming international help in this effort. At the same time, American experience and technology can, in many cases, be applied or adapted to the Chinese situation. Furthermore, green American innovations can take advantage of the Chinese market to achieve economies of scale and become competitive with older, energy intensive products. Thus building energy efficiency presents an important opportunity for U.S.-China cooperation. Below, this brief will examine the different aspects of problems and prospects with building efficiency in China, prospects for U.S.-China cooperation, and obstacles that should be addressed to facilitate such cooperation.

GREENING CONSTRUCTION—MATERIALS AND PROCESSES

One of the most energy intensive stages of a building's lifecycle is the manufacturing of the materials needed to build it. Sources of energy use in building construction include raw material extraction, material manufacturing, transportation, and construction. It is estimated that for China's commercial buildings, over forty percent of the energy a building consumes in its lifetime is used in producing these materials.[7] This equates to over a thousand kilograms of CO_2 emissions per square meter of building space in material production alone.[8]

Two key materials are timber and cement. Although according to the Chinese government the domestic timber industry is sustainable, imports of industrial timber have tripled since 1993, and the construction and furnishing sectors alone consumed 90 million cubic meters of timber in 2003. Many of China's imports come from African countries such as Cameroon, Congo, and Liberia, where 50 to 90 percent of exports are illegal.[9] The decimation of protected forests and fuel used in transportation make timber's environmental impact larger than is commonly perceived.

Cement production in particular is especially energy intensive and a large source of air pollutants. For more information, see Environmental and Health Threats from Cement Production in China.

The Chinese government has passed several national laws and codes to improve building energy efficiency standards. The most recent are:

- The *Energy Conservation Law of China* was passed in 1997 and went into effect in 1998. It provides general guidelines for energy conservation, and Chapter 4 in particular calls for the use of energy efficient technologies in buildings such as insulation. [10]
- The *Designing Standard for Energy Conservation in Civil Building* went into force in 2006, and requires firms to use energy efficient building materials and technologies such as HVAC and lighting systems. [11]
- The *Evaluation Standard for Green Buildings* that was issued by the Chinese government in 2007 includes several approaches to reducing material and construction energy use. The use of recycled building materials such as regenerated concrete helps mitigate the energy spent on resource procurement.[12] Use of local resources reduces energy spent on transportation of materials.[13] Also, investment in higher quality, more durable materials such as high-strength steel and high performance concrete increases the lifespan of buildings, reducing the need for repair or frequent construction of new buildings.[14]
- A *Special Plan for Energy Efficient Building* is expected to be issued by the Ministry of Housing and Urban-Rural Construction (MHURC) by the end of 2009.[15]

GREENING DESIGN AND APPLIANCE USE

The second major source of energy inefficiency in Chinese buildings is in their design and appliance use. Most buildings in China have been designed and constructed without attention to energy use. At the same time, more than half the total floor area in China is in the north, where the heating season is 3 to 6 months long.[16] A study of residential buildings in five Chinese cities showed that only in the northern cities of Beijing and Shenyang was any insulation used. In these cities, weather stripping on windows was used in only 20 percent of households, and on doors in only 14 percent. Other forms of insulation were negligible.[17] Such trends lead to an overall increase in consumption intensity, as in the case of Shanghai, where between 1998 and 2005 energy intensity in commercial buildings increased by 31 percent.[18]

A related key concern is energy end-use equipment such as heating, ventilation and air conditioning (HVAC) systems. Space heaters and air conditioners are becoming more common and are being used more intensely. In urban households, air conditioner ownership rose from .34 units per 100 households in 1990 to 95 units in 2007.[19] Today, heating and air conditioning are the largest sources of energy consumption in building use.[20] However, installation of energy efficient HVAC systems is generally rejected by building managers due to the return-benefit timeframe of 5 to 10 years which is perceived as too long to be worthwhile by building owners.

In response to increasing energy intensity, many measures that would increase efficiency and can be implemented at low or no cost are gaining popularity. In future construction, taking into account room layout and window placement can help create more efficient spaces, reducing the need for artificial lighting and HVAC use. Installation of weather stripping, insulation of roofs, and use of low emission coating on windows can be implemented in new construction and in retrofits of existing buildings to greatly increase energy efficiency.

Efficiency through Improved Building Management Practices

Building management can in many cases have a large impact on energy efficiency, and is an aspect of building efficiency that can bring almost immediate results. Buildings that have eco-friendly designs require proper building management to achieve their savings, but even without modern efficient building technology, significant gains in efficiency can be achieved through management, as in the case of a 27,000 square meter office tower in Shanghai achieved a 20 percent reduction in energy use through low and no-cost operational changes.[21] U.S.-China cooperation on building management improvement has taken place, as in the following cases:

- The EPA's eeBuildings program worked with 2,500 building managers to improve operation of 60 million square meters of building space from 2001 to 2008.
- In 2007, the US EPA and MHURC agreed to work to further the building operational improvement strategy develop a Chinese building energy performance rating system.
- The U.S. Agency for International Development is currently supporting a program to develop a prototype building energy performance rating system.

Interest and Markets

Cooperation between the United States and China on building energy efficiency has good prospects, but obstacles exist as well. For one, Chinese interest is limited in some ways, as in the case of new building construction. Construction firms would pay an average of 12.5 U.S. dollars extra per square meter of building space in order to follow the guidelines of *Designing Standard for Energy Conservation in Civil Building*. However, according to a real estate agent in Beijing there is little interest in green buildings on the part of buyers; location, apartment design, and the neighborhood environment are customers' top concerns, and 70 percent of clients don't take efficiency into consideration at all.[22] Thus construction firms see measures to increase efficiency as costs that cannot be passed on to consumers, and are therefore undesirable.

In existing buildings, although there is generally interest in no and low cost methods of energy efficiency, more costly actions such as installation of efficient HVAC units and insulation are coolly received. Many new buildings already have Western HVAC systems installed from companies such as Siemens or Carrier. There is little incentive to retrofit structures that are perceived as fully functional, and just getting new equipment in can be logistically problematic. According to Don Anderson of ICF International, "Sometimes you need to tear down walls, sometimes you have to disassemble the old equipment with a blowtorch; there's a lot of stuff that makes it challenging," and firms that are interested in retrofitting may not have the capacity to do so. Even when retrofits pay for themselves, in a highly competitive building management industry, building management firms are hesitant to suggest costly technology replacement to building owners, and a reluctance to spend money on new buildings has likely increased with the economic downturn.[23] Additionally, some efficiency retrofits are not seen as cost saving because the government subsidizes electricity and gas.[24]

The question of market access is also a salient one in regards to cooperation. Green companies in the United States would have an interest in bringing their products and technologies to China. However, many companies face difficulties in accessing the Chinese market.[25] Many class B and C buildings may not be professionally managed or are in government portfolios, which are difficult to gain access to. This, in combination with a lack of information about the quality of technology and propensity to spend in such buildings, makes them unattractive to both foreign firms interested in marketing technology upgrades, and those working on operational best practices.[26]

Foreign construction companies also face a number of bureaucratic and financial obstacles to working in China. Foreign firms must establish a legal entity in China in the form of a foreign enterprise or joint venture, and meet burdensome capital and staffing requirements to become a Foreign Invested Construction Enterprise (FICE), in order to do business. Foreign staff are required to reside in China for 3 to 6 months, depending on their position in the company. Wholly foreign-owned companies are extremely restricted, being only allowed to take on projects that Chinese firms cannot handle, and can only do so in cooperation with a Chinese firm. This effectively limits them to 10 percent of the Chinese market.[27]

EXISTING COOPERATIVE MODELS

Below are case studies of bilateral and private sector projects that reflect the prospects and challenges with U.S.-China cooperation on energy efficiency in buildings.

Operational Best Practices

The Asia-Pacific Partnership on Clean Development and Climate (APP) at the Department of States' Bureau of Oceans and International Environmental and Scientific Affairs and international consulting firm ICF International are implementing the *China Sustainable Building Operations Program* to improve energy production and efficiency in China through market-based methods. The APP Buildings and Appliances Taskforce is partnering with ICF International to introduce low and no cost operational best practices as well as limited technological upgrades through a market-based initiative to improve commercial building efficiency.[28] MHURC is also a major funder of the program, and if the project is successful, it may lead to a national program led by MHURC. Currently, the project is being implemented in Guangzhou, Chengdu, and Dalian, [29] and ICF international is working with the China Academy of Buildings Research to determine seven other cities for inclusion in the program.[30]

In order to implement this program, the China Sustainable Building Operations Program team is working through voluntary partnerships with building sector participants including property management associations and building portfolio managers within China to raise interest in improved building management.[31] It is focusing on Class A buildings that will act as flagship exemplars of improvements that can be achieved through operational best practices, and is working with larger management firms possessed of extensive portfolios across China in order to encourage diffusion of the information and practices it provides throughout the management community.[32]

The China Sustainable Building Operations Program is a successor activity to the Environmental Protection Agency's eeBuildings program, a pilot project that shared lessons learned from the U.S. ENERGY STAR® buildings program with the Chinese existing buildings marketplace. The China Sustainable Building Operations Program provides an energy performance monitoring tool to property managers[33], and trains them in energy efficient building operations and management practices, such as efficient use of parking garage ventilation systems. It is necessary to exhaust the air in parking garages due to carbon monoxide buildup in the atmosphere, and typically property managers leave exhaust systems on for long periods of time. However, it is possible to gauge carbon monoxide levels and run the ventilation systems accordingly, thus reducing energy use.[34] Such measures prove highly effective; through measure such as replacing sliding doors with revolving doors and optimizing the building pressure balance, the Jin Mao Tower in Shanghai was able to reduce its energy consumption by twenty percent,[35] The China Sustainable Buildings Program team is working to further two broader program goals. The first is to reach a wider audience by demonstrating that the process of operational improvement leads to successful energy efficiency improvements in buildings such as the Jin Mao Tower and provide technical guidance as to how this success can be replicated in order to encourage broader use of energy saving techniques. Secondly, the program is helping to gather information to contribute towards a national Chinese building performance benchmark which will provide a baseline to judge improvements in energy efficiency. This would facilitate performance comparisons, making it possible to judge the success of programs and designs to improve efficiency.[36]

Construction and Design

One of the ways that China is managing its rapid urbanization is by building massive residential blocks of two thousand to ten thousand units, called superblocks. It is estimated that ten to fifteen superblocks are built every day. Instead of constructing superblocks, Harrison Fraker, Dean of the College of Environmental Design at Berkeley, believes that an "Ecoblock" would be a viable alternative that would be sustainable. Ecoblocks would take advantage of common energy conservation technology such as insulation, passive ventilation, and efficient appliances to reduce energy use. The rest of the ecoblock's energy would come from wind and solar power generated on sight, along with biogas generation from sewage and organic waste that would be processed in constructed wetlands. Since sewage is processed on site, the water could be recycled and fed from rainwater capture, requiring much lower usage levels of municipal supplies. Although developers would have to foot the bill for the technology in these ecoblocks, Fraker posits that if developers were also managers of the ecoblocks, they would be able to charge for energy use at rates similar to those of municipal power utilities, thus making back their investment. [37]

Conclusion

Building energy efficiency in China presents both challenges and economic opportunities. Despite some false starts such as the stalled Dongtan Eco-city, Chinese business and government have made headway in facing these challenges and seizing opportunities, and U.S. businesses, NGOs, and government entities have begun to find a niche as well. However, further cooperation in terms of information sharing and technological development will benefit both sides economically and the world environmentally.

Alan Campana is a Summer/Fall 2009 Research Intern with the China Environment Forum and M.A. candidate at the Elliott School of International Affairs at the George Washington University, focusing on East Asian studies and non-traditional security. *He would like to thank Don Anderson and Meghan Aminto for sharing their experience and expertise.*

---

[1] "Building Materials: Energy Efficient Green Building Materials," International Trade Administration, United States Department of Commerce, page 1. [Online] http://www.ita.doc.gov/td/standards/Final%20Site/Country%20Information/China/Green%20Building%20Materials%20-%20Final%20AS%20sent%20to%20FCS%2011-7-06.pdf

[2] David Hathaway. (2009, May 4). "Reducing Energy Use at Low Cost," *China Dialogue.* [Online] http://www.chinadialogue.net/article/show/single/en/2975

[3] "Building Materials: Energy Efficient Green Building Materials," pp. 1

[4] Karen C. Economy. (2007, Sep./Oct.). "The Great Leap Backward?" *Foreign Affairs.* [Online] http://www.foreignaffairs.com/articles/62827/elizabeth-c-economy/the-great-leap-backward

[5] Kenneth Langer and Robert Watson. (2004, November 1). "The Greening of China's Building Industry," *China Business Review.* [Online] http://www.chinabusinessreview.com/public/0411/langer.html

[6] Martin Joerss, Jonathan R. Woetzel, and Haimeng Zhang. (2009, May) "China's green opportunity." Mckinsey Quarterly. [Online]

http://www.mckinseyquarterly.com/Economic_Studies/Productivity_Performance/Chinas_green_opportunity_2364?gp=1

[7] David G. Fridley, Nina Zheng and Nan Zhou. (2008, March). "Estimating Total Energy Consumption and Emissions of China's Commercial and Office Buildings," Ernest Orlando Lawrence Berkeley National Laboratory, Environmental Energy Technology Division, LBNL – 248E, page 18. [Online] http://china.lbl.gov/publications/estimating-total-energy-consumption-and-emissions-chinas-commercial-and-office-building

[8] Ibid, pp. 21

[9] Tina Butler. (2005 April 20) "Growing Pains and Growing Alliances: China, Timber and Africa." Mongabay.com [Online] http://news.mongabay.com/2005/0420x-tina_butler.html

[10] *Energy Conservation Law of China*, (1997, 1 November) Presidential Act of the People's Republic of China No. 90 [Online] http://www.unescap.org/esd/energy/publications/compend/ceccpart4chapter4.htm

[11] "China mandates energy efficiency standard in urban construction," People's Daily Online. (2006 February 25)[Online] http://english.people.com.cn/200602/25/eng20060225_245935.html

[12] "Standard by People's Republic of China: Evaluation Standard for Green Buildings," GB/T 50378-2006, 4.4.9 [Online] http://docs.google.com/Doc?id=ddfqxmx9_29hs74dhgv

[13] Ibid, 4.4.3

[14] Ibid, 4.4.5

[15] "China Standards and Certification Fact Sheet," International Trade Administration, United States Department of Commerce, page 1. [Online] http://www.ita.doc.gov/td/standards/pdf%20files/China%20Standards%20Fact%20Sheet%20-%20Green%20Building%20Materials.pdf

[16] Siwei Lang, Yu Joe Huang. (2004, December) "Progress in energy-efficiency standards for residential buildings in China," *Energy and Buildings*, Volume 36, Issue 12. page 1192.

[17] Debbie Brockett, David Fridley, Jieming Lin, Jiang Lin. "A Tale of Five Cities: The China Residential Energy Consumption Survey," Lawrence Berkeley National Laboratory. page 8.32. [Online] http://eetd.lbl.gov/ea/China/publications/crecs.pdf

[18] Florian Bressand, Nan Zhou, Jiang Lin. (2007) "Energy use in commercial building in China: Current situation and future scenarios," from Sophie Attali, Kenya Tillerson (Eds.) *eceee 2007 Summer Study: Saving Energy – Just do it! Conference Proceedings,* European Council for an Energy Efficient Economy, Stockholm: ABA Intercopy. pp. 1068. [Online]: http://www.eceee.org/conference_proceedings/eceee/2007/Panel_5/5.312/Paper/

[19] National Bureau of Statistics of China, *China Statistical Yearbook 2008*, 9-10 Ownership of Major Durable Consumer Goods Per 100 Urban Households at Year-end. [Online] http://www.stats.gov.cn/tjsj/ndsj/2008/html/J0910e.htm

[20] Lang, pp. 1192

[21] Hathaway

[22] "China mandates energy efficiency standard in urban construction," People's Daily Online. (2006 February 25)[Online] http://english.people.com.cn/200602/25/eng20060225_245935.html

[23] Don Anderson, personal communication. July 6, 2009.

[24] Ariane Wu. (2009, May) "Building a Greener China," *Far Eastern Economic Review*, [Online] http://www.feer.com/international-relations/20098/may56/Building-a-Greener-China

[25] Transcript, Hearing of the Senate Committee on Foreign Relations. Subject: Challenges and Opportunities for U.S.-China Cooperation on Climate Change. Chaired By: Senator John. F. Kerry. June 4, 2009. page. 24. [Online] http://www.carnegieendowment.org/files/0604_transcript.pdf

[26] Don Anderson, personal communication. July 6, 2009.

[27] The American Chamber of Commerce in the People's Republic of China. *American Business in China: 2009 White Paper*. Pages 160-162. [Online] http://www.amchamchina.org/article/4142

[28] Department of State, Asia Pacific Partnership on Clean Development and Climate. BATF 09-051. [Online] http://www.asiapacificpartnership.org/pdf/Projects/BATF/CPD/BATF-09-51.pdf

[29] Department of State, Asia Pacific Partnership on Clean Development and Climate. BATF 09-051 update. [Online] http://www.asiapacificpartnership.org/pdf/Projects/BATF/BATF-09-51.pdf

[30] Meghan Aminto, personal communication. July 6, 2009.

[31] Meghan Aminto, personal communication. July 6, 2009.

[32] Don Anderson, personal communication. July 6, 2009.

[33] Meghan Aminto, personal communication. July 6, 2009.

[34] Don Anderson, personal communication. July 6, 2009.
[35] "Case Study: Jin Mao Tower Reduces Energy Use by 20% Through Low-Cost and No-Cost Operational and Retrofit Measures," United States Environmental Protection Agency. [Online] http://www.epa.gov/eeBuildings/files.cgi/834_Jim_Mao_revised-WITHPICT-May2006.pdf
[36] Don Anderson, personal communication. July 6, 2009.
[37] http://www.greendragonfilm.com/qingdao_ecoblock_project.html