A CHINA ENVIRONMENTAL HEALTH PROJECT FACT SHEET

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

China's Power in Wastewater

January 2009

By Jenny Lieu

China has been utilizing small-scale biogas technology in rural areas since as early as the nineteenth century, with applications first appearing in the southern coastal regions and spreading throughout the Yangtze River Basin. In the late 1950s, municipal officials in the city of Wuchang, Hebei Province applied biogas digesters at a wider scale to address sanitation and health issues and use landfill waste to provide a source of alternative energy. In the 1970s and 1980s, the Chinese government promoted biogas technology more broadly in rural areas to modernize agriculture practices as well as to improve the health of farming families. Rural families have long suffered adverse health effects from inhaling the fumes and particulates released from burning wood indoors for cooking and heating, so utilizing clean-burning biogas considerably improved their quality of life. Furthermore, biogas technology provided rural households with electricity, as the homes were often remotely located without direct access to the main electricity grid.[1] Strikingly, in China today biogas applications are now expanding to the urban municipal and commercial wastewater treatment sector, which offers solutions to China's severe pollution from wastewater and pressing energy needs in cities.

FRAGILE FOUNDATION OF WEALTH

Overall China's impressive real GDP growth of 11.9 percent in 2007 illustrates the vast potential of the economy. Moreover, if total Purchasing Power Parity GDP was the sole indictor used to determine national prosperity, China would rank as the second wealthiest nation in the world with a GDP totalling to $7.099 trillion. However, as impressive this figure may be, $7 trillion spread amongst 1.3 billion citizens amounts to $5,400 GDP per capita—whereas the United States maintains a GDP per capita of $45,800. Although a seemingly modest 8 percent of the population lives below the poverty line, a total of 21.5 million rural dwellers live on the absolute poverty line of $90 per year. Additionally, another 35.5 million in the rural region live on $125 per year, which is the low-income line.[2]

Poverty in China is also exacerbated by severe environmental problems, particularly access to clean water. Water shortages and increasingly degraded water combined with the lack of affordable healthcare in rural China have made the burden of disease heavier in the countryside, which perpetuates a cycle of poverty (See CEHP Research Brief "Water-Borne Illnesses in China"). Of China's 1.3 billion citizens, 260 million—or 20 percent of the population—faced water scarcity in 2007. Furthermore, only 678 million citizens—or 52 percent of the population—are connected to wastewater treatment facilities.[3] The untreated municipal wastewater is the leading source of pollution in China's rivers and has led some 400 cities to suffer from inadequate access to clean water.[4] In 2007, China's Ministry of Health began releasing statistics linking increases in polluted water and air with growing rates of cancer in urban and rural areas.

Ultimately China's water pollution problems pose serious threats to human health and economic growth. While there are no quick fixes to China's water pollution crises, wastewater to biogas represents one promising technology that addresses China's main source of water pollution—municipal wastewater—and opens up a potentially successful source of renewable energy.

CHINA'S THIRST FOR ENERGY

In 2008, the Chinese government estimated an energy shortfall of at least 10 GW, which is only approximately 1.4 percent of the total installed energy capacity.[5] However, the actual energy deficit likely exceeded the estimation in 2008 partially due to depleted coal resources at existing mines and several natural

disasters. Provinces including Shanxi, Guangdong, Shandong, and Sichuan are predicted to face power shortages two times the expected national shortfall.

As the second largest energy consumer globally, China rivals the United States with expectations to become the world's largest energy consumer as early as 2010. China has undoubtedly become a major global player in the energy market accounting for 15 percent of the global primary energy demand and is predicted to increase its share to 20 percent by 2030. Due to the sheer size of the country's energy demands, incremental changes in China's energy demand will result in considerable global impacts. If the average annual growth rate of China's primary energy demand grows by 1 percent in 2030, this would raise the world primary energy demand by 6 percent.[6]

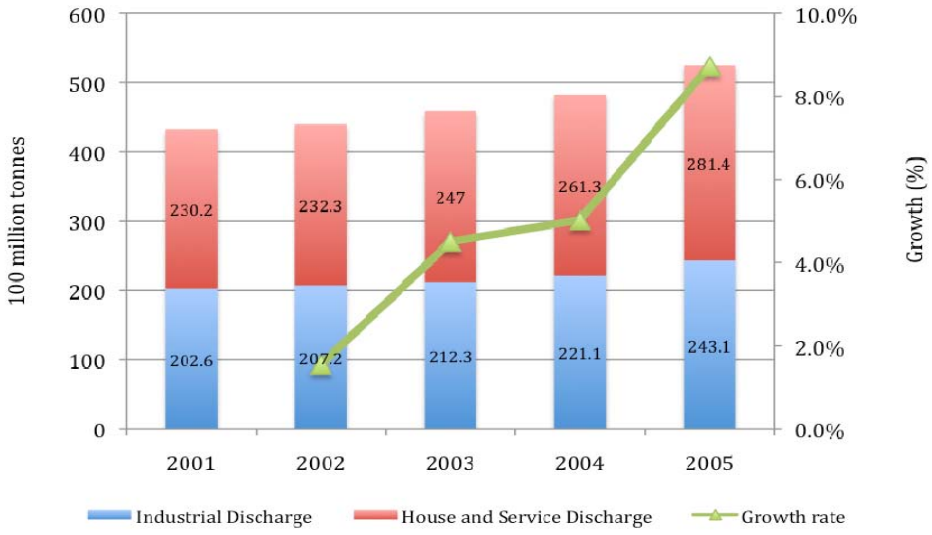
Furthermore, electricity consumption in China amounted to 2,197 TWh in 2005. By 2006, China's electricity consumption increased by approximately 30 percent over that in 2005, reaching 2,859 TWh.[7] In order to meet the rapidly growing electricity demand, the International Energy Agency (IEA) predicts that China must increase its electricity generating capacity by over 1,300 GW by 2030, which is greater than the total installed capacity in the United States at present.

FLOODS OF WASTEWATER

Efficient water management is a challenging goal to achieve in China, as the country must simultaneously tackle water scarcity, improve access to wastewater coverage, and increase the quality of treatment. Meeting the central government's wastewater treatment goals is an increasingly difficult task as wastewater discharge has risen over the past years and local governments are often lax in even turning on treatment facilities that have been built due to the high energy costs of running such plants.

The massive increase in wastewater is partly due to China's high industrial production growth rate, which rose from 9.9 percent in 2001 to 27.7 percent in 2005.[8] Even with the slight slowdown in industrial growth over the past several years, the quantity of wastewater discharged from the industrial sector continues to exhibit an upward trend, as illustrated in Table 1. For instance in 2006 alone, 24.31 billion tons of wastewater was discharged from the industrial sector.[9]

Table 1: Growth of Industrial and Municipal Wastewater Discharge in China



Source: *China Environmental Statistical Yearbook*, 2006

Furthermore, rapid development of the manufacturing sector, particularly in water intensive industries, has escalated China's environmental issues. The energy sector (including coal mining), chemicals, metals, textiles, as well as, the food and beverage sectors are among the key industries that have been responsible for discharging large quantities of treated and untreated wastewater into China's water bodies.

Population increase, and associated increases in wastewater, has also placed strains on China's water resources. The Chinese government has placed great efforts on minimizing population growth with the one child policy; however, due to the large existing population, even a minute population growth of 0.629 percent, as observed in 2007, results in an increase of roughly 8.3 million people a year.[10] While more people put greater demands on water, per capita water usage in China remains quite low, a quarter of global per capita water use.

In addition to increasing wastewater coverage to meet the demand of the existing and growing population, China also must modernize its present infrastructure to provide secondary treatment—augmenting primary wastewater treatment—in order to meet international standards.[11] Tertiary wastewater treatment may also be required as an additional purification step.[12] The key focus is to provide a standard secondary wastewater treatment that involves anaerobic digestion, which removes organic content remaining from the primary treatment and generates biogas, a valuable renewable energy source.

BIOGAS: AN INTEGRATED ENERGY & ENVIRONMENT SOLUTION

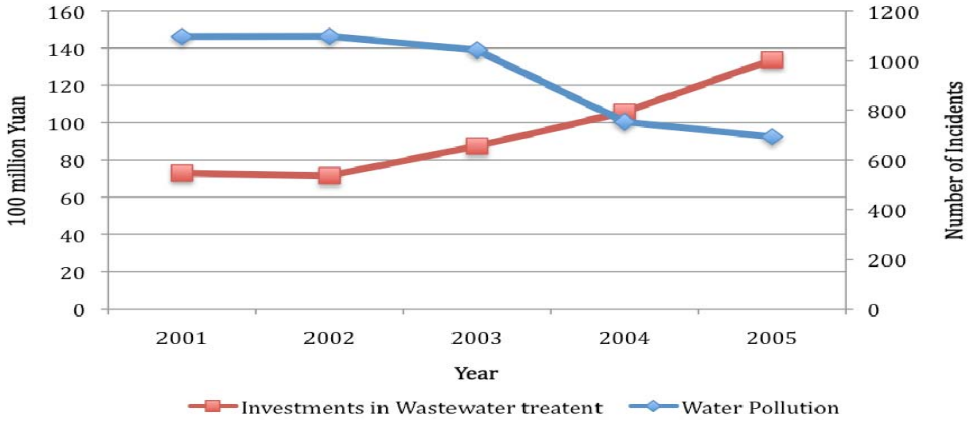
Biogas is created from the anaerobic digestion of biodegradable matters, such as wastewater, and converted into a clean energy source. Gases are produced during the digestion process when bacteria break down organic waste. This process occurs in nature and is often observed in the bottom of lakes, swamps, ponds, and animal intestines.

This anaerobic process occurs in the absence of oxygen, bacteria break down organic matter into methane (CH_4), carbon dioxide (CO_2), sulphur dioxide (H_2S), and heat energy. Methane, a highly combustible and odourless gas, usually makes up 60 to 65 percent of the overall biogas production and is comparable to natural gas, which is comprised of approximately 99 percent methane. When methane is captured in the anaerobic process, the gas may be stored and utilized on site or may be sold to the local energy grid. However, when untreated wastewater is directly disposed into water bodies, the natural anaerobic process occurs and releases methane, causing significant damage to the environment and contributing to global climate change, as one ton of methane gas is equivalent to 21 tons of CO_2. Investing in wastewater to biogas applications will not only help clean polluted water bodies but will also contribute to alleviating energy shortage, increasing energy security, and reducing carbon emissions.

CHINA'S RESPONSE

China has been tackling the issue of water pollution in the last decade by setting obligations for all large and middle-sized cities to construct wastewater treatment plants. Furthermore, increased investments in the wastewater treatment sector have resulted in decreased water pollution, as indicated in the graph below.

Graph 1: Relationship between Investment in Wastewater Treatment and the Amount of Water Pollution



Source: China Environmental Statistical Yearbook, 2006

When the amount of funding allocated to wastewater treatment is plotted against the number of water pollution incidents, the trend shows that a greater amount of investment results in decreased water pollution. Greater investments also results in a high wastewater treatment rate in municipalities, improving quality of life for many citizens. For instance, in 2002, 500 wastewater treatment plants were in operation indicating a treatment rate of 39.9 percent, while in 2005 the rate rose to an average of 45 percent.[13] Furthermore, Chinese cities have applied wastewater to biogas treatment technologies, such as the anaerobic-aerobic activated sludge process that addresses both energy and environmental protection. Anaerobic-aerobic technologies have been recently installed in various regions in China. For instance, the Jiaonan City Wastewater Treatment Plant in Shandong was completed in 2005 using the anaerobic-aerobic activated sludge nitrogen removal process while the Baoan District Wastewater Treatment Plant located in Guangdong applied the anaerobic-anoxic-aerobic activated sludge process within its wastewater treatment facilities in 2007.[14]

Overall energy and environment issues are gaining greater political awareness and China has responded by placing the two areas as priority issues within its national plans. For instance, China has an ambitious target to decrease energy consumption by 20 percent per unit of GDP over the 2006-2010 period in addition to cutting emissions by 10 percent. *The National Energy Strategy and Policy* has proposed targets for renewable energy to contribute between 12 and 16 percent of the overall primary energy by 2020.[15] Within these targets, biogas and biomass gasification is expected to produce 44 billion m^3 of gas per annum (~264 GWh/annum) by 2020, as cited in Table 2, which is equivalent to 11.4 billion m^3 of natural gas per annum (~68.4 GWh/annum).[16] Thus, biogas will be instrumental in meeting China's renewable energy target.[17]

Table 2: Chinese Renewable Energy Targets

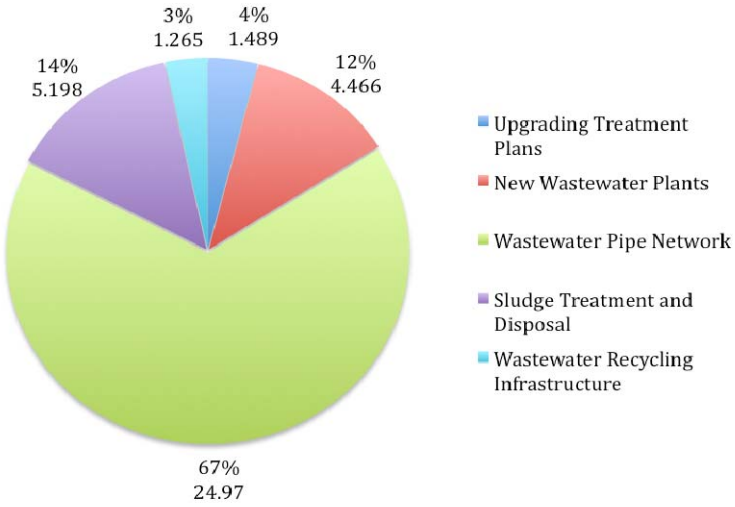
Target	2006 Actual	2010 Target	2020 Target
Hydro power	130 GW	190 GW	300 GW
Wind power	2.6 GW	5 GW	30 GW
Biomass power	2 GW	5 GW	30 GW
Solar PV	0.08 GW	0.3 GW	1.8 GW
Solar hot water	100 million m^2	150 million m^2-	300 million m^2
Ethanol (grain and non-grain)	1 million tons	2 million tons	10 million tons

Biodiesel	0.05 million tons	0.2 million tons-	2 million tons
Biomass pellets	~ 0	1 million tons	50 million tons
Biogas and biomass gasification	8 billion m^3/year	19 billion m^3/year	44 billion m^3/year

Sources: Actual 2006 per Martinot and Li 2007; targets per NDRC, Medium and Long-term Development Plan for Renewable Energy in China (September 2007) (Cited in Martinot, 2007)

In addition to the renewable energy targets, which biogas will contribute to, China has set 301.4 billion Yuan ($37 billion) aside for its in National Urban Wastewater Treatment and Recycling Infrastructure in its 11th Five-Year Program. The Chart below depicts the allocation of funds.

Chart 1: China's Investments in its National Urban Wastewater Treatment and Recycling Infrastructure in Billions (2006-2010)



Source: Department of Environmental Science & Engineering, Tsinghua University, 2006

Approximately 30 percent of the funds will be directed towards upgrading and building the wastewater treatment infrastructure, which could potentially include anaerobic digestion. There is also a large potential for municipal sludge treatment, which may utilise the anaerobic digestion process to treat effluent for fertilizer use. This diverts sludge from landfills and also generates biogas, an energy source that can be applied back into the wastewater treatment system, thus reducing the need for conventional fuel to run the system. Furthermore, there are significant opportunities for biogas applications within the industrial wastewater sector: As the Chinese Academy of Sciences and Geography estimates, 80 percent of the effluent discharged may be treated anaerobically.

China has a vast potential to be among the leading producers of biogas from wastewater due to its large population and sizable industrial sector. However, tapping into the potential will be a monumental task. The Chinese authorities must continue to provide adequate funding, attract foreign investors to take part in large wastewater to biogas treatment projects, as well as, set and properly enforce environmental legislation and standards. Meeting the objective will require high commitment from the government and years of continuous investment.

Jenny Lieu is a doctorate student at SPRU- Science Technology Policy Research where she is focusing on renewable energy policy in China within SPRU's Sussex Energy Group. Her research specifically examines how China has translated policy models from Europe and abroad into its own renewable energy policy framework. She can be reached at J.Lieu@sussex.ac.uk.

[1] The Institute of Science in Society. (2006, October 2). Biogas China. [Online]. Available: http://www.i-sis.org.uk/BiogasChina.php.

[2] CIA, Central Intelligence Agency. (2008, October 9). *The World Fact Book: China.*. [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html.

[3] Global Water Intelligenve. (2008). *China: Country Snapshot.* Oxford: Media Analytics Ltd.

[4] Jie, Z., Cao, X.-S., & Meng, X.-Z. (2006). Sustainable urban sewerage system and its application in China. *Resources Conservation & Recycling , 51*, 284-293.

[5] Bai, J. (2008, July 11). "China power woes may worsen before Olympics." *Energy Investment Strategies*. (Reuters (Beijing)). [Online]. Available: http://www.energyinvestmentstrategies.com/2008/07/11/china-coal-shortages-could-raise-their-oil-use/.

[6] International Energy Agency, IEA. (2006). *World Energy Outlook 2006*. Paris: OECD/IEA.

[7] CIA, Central Intelligence Agency. (2008, October 9). *The World Fact Book: China.* [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html.

[8] CIA, Central Intelligence Agency. (2005-2008). *The World Fact Book: China.* [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html.

9 *China Daily*. (2006, October 16). China clamps down on industrial pollution. [Online]. Available: http://english.peopledaily.com.cn/200610/16/eng20061016_312075.html.

[10] CIA, Central Intelligence Agency. (2008, October 9). *The World Fact Book: China.* [Online]. Available: https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html.

[11] Primary wastewater treatment is often the first step from wastewater treatment that involves the removal of solid debris and suspended organic from the wastewater such as fats, oils, and greases.

[12] Tertiary wastewater treatment is the often the final treatment process, usually consisting of an advanced disinfection processes, such as using Ultra Violet to further purify the wastewater, eliminating bacteria remaining from the secondary treatment. This process is usually required when before discharging effluent into sensitive environments.

[13] U.S. Deparment of Commerce, International Trade Administration. (2005). Water Supply and Wastewater Treatment Market in China. U.S. Deparment of Commerce. Washington: International Trade Administration.

[14] U.S. Department of Commerce. (January, 2005). International Trade Administration. [Online]. Available: http://www.icwt.net/China%20Water.pdf.

[15] China Strategies, L.L.C. (2007 December). *China Renewable Energy and Sustainable Development Report.* Vol. XII. [Online]. Available: http://www.renewableenergyaccess.com/assets/documents/2007/China_RE_Report_December_2007.pdf.

[16] Assuming that the calorific value of biogas is approximately 6 kWh/m^3.

[17] China Strategies, L.L.C. (2007 December). *China Renewable Energy and Sustainable Development Report.* Vol. XII Retrieved October, 2008 from [Online]. Available: http://www.renewableenergyaccess.com/assets/documents/2007/China_RE_Report_December_2007.pdf.