SLUDGE TREATMENT IN CHINA

Market opportunities for sludge treatment, re-use and disposal

Autumn 2011
About the China Greentech Initiative

Founded in 2008, the China Greentech Initiative (CGTI) Partner Program has rapidly grown to become the only China-international collaboration platform of 100+ organizations, focused on identifying, developing and promoting green technology solutions in China. Partnering organizations are technology buyers and sellers, service providers, investors, policy makers and influencers. Sector tracks addressed during the 2011 CGTI Partner Program include Cleaner Conventional Energy, Renewable Energy, Electric Power Infrastructure, Green Building, Cleaner Transportation and Clean Water.

Built on two cornerstones, strategic market research and a community of 300+ industry experts, CGTI provides participating organizations with three core areas of benefit: world class market insights that enable better decisions, meaningful relationships that lead to business opportunities, and thought leadership and education that position participants as leaders in China’s greentech markets.

In addition to the Partner Program, CGTI offers Advisory Services, conducts briefings and publishes public content, including White Papers and the annual China Greentech Report. The flagship China Greentech Report 2009, released at the World Economic Forum, together with the China Greentech Report 2011, have helped establish CGTI as the authority on China’s ever evolving greentech markets.

Clean Water Sector Definition

CGTI defines the Clean Water Sector as activities across the economic water cycle – water extraction, water treatment, water distribution, water use and wastewater treatment – and solutions, such as water treatment technologies, water quality measurement, monitoring and efficient point-of-use equipment.

- **Water Extraction**: Provision or extraction of water resources from the biosphere to original water rights holders
- **Water Treatment**: Processes by which raw water is made ready for use
- **Water Distribution**: Transportation of treated water to end users
- **Water Use**: Consumption of water by agricultural, industrial or domestic users
- **Wastewater Treatment**: Collection and cleansing of water discharged after consumption for secondary consumption or release back to nature
Executive Summary

Sludge treatment and disposal should represent a huge market opportunity, given the estimated 22 to 30 million tons of sludge discharged annually from wastewater treatment in China, but the lack of a comprehensive policy framework and inadequate enforcement have held back the market.

China’s growing municipal wastewater treatment network has led to a rapid expansion of residual sludge. Sludge discharge has grown 5% annually over the past five years, and is now estimated to reach 22 to 30 million tons annually. Microorganisms and pathogens, unpleasant odors, emission of CH$_4$ gases, and in some cases heavy metal content make sludge a harmful by-product of wastewater treatment requiring proper treatment and disposal. Yet sludge regulation is highly fragmented and lacks a comprehensive framework—for example, there is no national standard sludge treatment fee. Due to inadequate incentives, the industry has stuck with low-cost, potentially unsafe disposal in landfills—or worse, direct discharge into the environment—despite the existence of technologies to convert sludge into a valuable resource. Nevertheless, recent developments in the sector indicate growing private sector confidence in the sludge treatment market.

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<th>Definition and Scope</th>
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This White Paper’s objective is to understand sludge treatment and disposal market opportunities in China, including market trends, regulatory developments, treatment and disposal solutions, plant economics, and applicable business models. The White Paper focuses on the treatment of sludge produced during the municipal wastewater treatment process and treated either on-site in wastewater treatment plants or in centralized sludge treatment facilities. This White Paper does not cover sludge discharged from a dedicated industrial wastewater treatment process, where sludge composition can differ greatly from municipal sludge.

In analyzing the sludge treatment opportunities in China, CGTI addresses the following areas:

- **Market**: The White Paper evaluates the market size for sludge treatment and disposal in China over the next five years, as well as major market developments.
- **Regulatory context**: The White Paper looks at steps policy makers have taken or are considering taking to regulate and promote the sludge treatment and disposal market.
- **Solutions and economics**: CGTI examines the main technology solutions being adopted in China as well as opportunities to reduce costs or increase revenues from treatment or disposal. Using a sensitivity analysis, the White Paper examines the economics of advanced sludge treatment versus other, less-environmentally attractive disposal such as landfiling.
- **Industry value chain and business models**: The White Paper examines strategies and business models of private companies currently participating in the sludge treatment sector.

Finally, CGTI and its Partners identify means by which various industry stakeholders (including government, public and private players) could accelerate the sludge treatment market.
Market Analysis

Sludge poses a growing environmental threat in China, ironically due to rapid improvements in municipal wastewater treatment. Between 22 and 30 million tons now require treatment annually, but 80-90% of sludge is still disposed in landfills and other improper ways.

Improper sludge disposal is a growing hazard

In September 2009, a major sludge pollution trial opened in Beijing against five people accused of releasing at least 6,500 tons of municipal wastewater treatment sludge containing toxic heavy metals into the Mentougou water conservation district just west of Beijing. The dumping led to estimated economic losses of RMB 100 million. One of the accused, He Tao, explained that since starting his business in 2002, he either sold untreated sludge as fertilizer or discharged it directly on banks of rivers. “In our industry, before 2008 most companies used to do exactly the same,” he said.¹

The Mentougou case is hardly an isolated incident. In Guangdong, the province with the largest municipal wastewater network, the Nanfang Daily reported in 2009 that over 90% of sludge was improperly landfilled.² Improper sludge disposal can pollute soils, contaminate nearby water bodies and groundwater, and release methane. Improper sludge disposal not only threatens destruction of valuable land, soil and water, but also means loss of potentially recoverable resources—however, sludge is not inherently useless waste.

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² Nanfang Daily, “广东九成污泥填埋为害甚于污水 行业标准混乱.” [90% of sludge is improperly landfilled in Guangdong, as confusion surrounds industry standards], Oct. 14, 2011
China’s sludge output is growing rapidly due to the expansion of municipal wastewater treatment infrastructure. The number of municipal wastewater plants in China has more than tripled from 718 in 2005 to 2,823 in 2010. This figure is set to exceed 5,200 in 2012, representing an annual growth of 31%. Based on 38 billion tons of municipal wastewater discharged in 2010, China produced roughly 22.8 million tons of sludge.\(^3\) China’s Ministry of Housing and Urban Development (MOHURD) estimates 22 million tons annually whereas some industry experts have quoted figures of up to 30 million tons.\(^4\) How much sludge is that? 22.8 million tons is equivalent to one-seventh of China’s total municipal solid waste collections, and would fill 1.6 million 14-ton trucks, or roughly 80% of China’s total truck fleet.\(^5\) The figure is also roughly similar to Spain’s total municipal wastewater volume—and China’s sludge output is still rapidly rising. In any case, the growth in municipal wastewater treatment and requirements for new plants to include sludge treatment will lead to a rising market for sludge treatment and disposal.

Which regions of China produce the most sludge? China’s 10 coastal provinces represent the largest share of sludge discharge, reflecting higher concentration of population, urbanization, and more developed wastewater treatment infrastructure—these provinces produce around 56% of China’s wastewater output as of 2010.\(^6\) Guangdong, China’s most populous province, produces the most sludge annually at an estimated 3 million tons, roughly 13% of total sludge output.\(^7\)

How does China dispose of sludge now? There are no official data on sludge disposal, rather conflicting sources with different estimates. From one Tsinghua estimate, 48% of sludge goes to fertilizer, 34% to landfills, and an astonishing 14% is discharged into the environment.\(^8\) The remaining 4% is incinerated or used in other ways. Data from water utility Sino-French Water indicates that 61% is landfilled.\(^9\) In some areas, such as Guangdong, landfills account for 90% of sludge disposal.\(^10\) Since 2007 China has not permitted sludge with over 60% water content in landfills—theoretically barring most wastewater treatment plants from discharging sludge without sufficient dewatering treatment.\(^11\) Yet actual enforcement at the local level raises concerns. Sludge use for fertilizer may also pose problems given its heavy metal content.

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\(^7\) Ibid.; CGTI analysis

\(^8\) Jiane Zuo, “Status and Development of Sewage Sludge Treatment and Disposal in China,” *Tsinghua University*, Apr. 30, 2010


\(^10\) Nanfang Daily, “广东九成污泥填埋为害甚于污水 行业标准混乱,” [90% of sludge is improperly landfilled in Guangdong, as confusion surrounds industry standards], Oct. 14, 2011

China could spend RMB 4.7 billion to treat sludge annually by 2015

Sludge treatment can take place at either central or decentralized facilities. A centralized treatment plant takes in sludge collections from a network of nearby wastewater treatment plants, offering lower per ton treatment costs due to economies of scale and improved efficiency due to specialized personnel. Centralized treatment also offers additional options to recover nutrients or biogas fuel from sludge. Decentralized facilities do offer some advantages: they require less upfront capital costs and do not require sludge collection or transportation. They are also easier to permit and locate than larger plants.

How big will the sludge treatment market be in 2015? To reach a theoretical 40% treatment rate, plants may require RMB 4.7 billion in operating costs per year by 2015, equivalent to four times the current levels. To reach this estimate, CGTI used a 4.7% annual municipal wastewater discharge growth rate from 2010 to forecast 2015 levels and a 10,000:6 wastewater-to-sludge ratio. Assuming operating cost at RMB 400/ton, and a treatment rate of 40%, this implies RMB 4.7 billion in annual operating expenses.

<table>
<thead>
<tr>
<th>Item</th>
<th>2010 – 20%</th>
<th>2015 – 30%</th>
<th>2015 – 40%</th>
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<tbody>
<tr>
<td>2010 urban wastewater discharge</td>
<td>38.9 billion tons</td>
<td>38.9 billion tons</td>
<td>38.9 billion tons</td>
</tr>
<tr>
<td>Average annual growth rate 2011-2015</td>
<td>-</td>
<td>3.3%</td>
<td>4.7%</td>
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<tr>
<td>Forecast municipal wastewater discharge</td>
<td>-</td>
<td>45.7 billion tons</td>
<td>48.9 billion tons</td>
</tr>
<tr>
<td>Forecast wet sludge discharge</td>
<td>23.3 million tons</td>
<td>27.4 million tons</td>
<td>29.3 million tons</td>
</tr>
<tr>
<td>Treatment rate</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
</tr>
<tr>
<td>Operating costs per unit</td>
<td>RMB 100-400 ton</td>
<td>RMB 200/ton</td>
<td>RMB 400/ton</td>
</tr>
<tr>
<td><strong>Annual operating costs</strong></td>
<td><strong>RMB 1.2 billion</strong></td>
<td><strong>RMB 1.6 billion</strong></td>
<td><strong>RMB 4.7 billion</strong></td>
</tr>
</tbody>
</table>

Note: Sludge discharge based on a wastewater to sludge volume ratio of 10,000:6
Sources:
4. CGTI analysis
China’s sludge industry faces many challenges ranging from lack of comprehensive policies to insufficient funding. Challenges related to the market and industry include:

- **Wide operating cost ranges**: The cost of handling, treating and disposing of sludge can range from as low as RMB 15 to over RMB 500 per ton.
- **Lack of operational expertise**: Due to the rapid increase in wastewater treatment in China, few companies have developed China-specific operational and technical expertise, and lack track records of effective long-term plant management.
- **Marketing claims**: Some new market entrants have aggressively sought market share and made promises their technology cannot deliver.\(^{12}\)

In addition, the industry faces a number of challenges related to regulations such as a lack of comprehensive national policies, enforcement, and funding. These are the focus of the next section.

**Regulatory context**

Though several provinces have set sludge treatment targets and fees, China lacks a comprehensive plan to achieve its targets—in particular, funding for sludge treatment is unclear.

**China lacks comprehensive standards, investment plans and treatment charges**

The central government has issued a sludge treatment technology guide and has announced plans to spend RMB 60 billion in sludge treatment over the 12th Five-Year Plan period—barely enough to meet infrastructure investment needs. The central government also has national targets for sludge treatment rates by 2015, but enforcement of existing rules has lagged. Sludge treatment is expensive and there is no national fee to compensate plants for wastewater treatment. Given the lack of national incentives, some provinces have taken the lead. Jiangsu and Guangdong are each considering sludge treatment charges, and other provinces have established safe treatment targets.\(^{13}\)

Since 2009, China has taken a number of important actions, including sludge technology guidelines and treatment standards. In 2009, the Circular Economy Promotion Law required county-level governments to support use by private enterprises of sludge treatment systems. In the same year, MOHURD and the Ministry of Environmental Protection issued technology standards, including preferred technologies and restrictions on sludge transportation and storage. This measure was followed a year later by guidelines on best-available technologies issued by the National Planning Commission (NPC).

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The central government's major regulation on sludge treatment to date is the Nov. 26, 2010, Notice on Reinforcing Municipal Wastewater Treatment Plant Sludge Pollution Prevention and Control. The measure requires municipal wastewater treatment plants to treat sludge and to install sludge treatment capacity within two years. In February 2011, the National Development and Reform Commission (NDRC) and MOHURD issued plans for setting up sludge treatment demonstration projects with advanced technologies, and urged provinces to set sludge treatment targets. Subsequently, in March, MOHURD and NDRC issued a trial guideline on treatment technologies.

As one CGTI Advisor noted, “Only when the government imposed the strictest wastewater discharge standards—Grade IA—did the wastewater treatment market take off. I expect the same to be true for sludge treatment in China.”

The 12th Five-Year Plan sets ambitious targets for sludge treatment nationally—some provinces will see their rate for safe treatment and disposal rise from roughly 20% to 80%—and reiterates the 2010 requirement that all municipal wastewater treatment plants must install sludge treatment equipment by 2012. The plan also sets investment plans of RMB 60 billion for sludge treatment infrastructure.

Though this investment plan sounds impressive, CGTI’s calculations suggest this funding amount will be barely enough to meet installation targets for 2012 and treatment targets for 2015. First, plant operation alone could cost almost RMB 5 billion annually, as noted above. Second, sludge treatment plant equipment usually ranges between RMB 250,000 and RMB 700,000 per ton per day depending on technology choice and location, meaning total capital costs to treat China’s current sludge discharge could fall within a RMB 15 to RMB 57 billion range. In the absence of a national sludge treatment fee included in water prices—and considering local governments’ stretched budgets—it appears there is no clear way to fund current central government mandates. The MOHURD technology guide suggested that provinces should include fees to fund sludge treatment, but so far only two provinces have moved forward on that recommendation. To date, wastewater treatment plant operators have viewed sludge treatment as an additional cost to be minimized. If enforcement continues to lag and plant owners lack incentives to treat sludge, abuses similar to the Mentougou case in Beijing will continue.

Several provinces are taking the lead on targets, enforcement and funding

To address the lack of national targets and funding for sludge treatment, several individual provinces have adopted their own plans, including Guangdong, Jiangsu, Hebei and Hubei.

- **Jiangsu** has adopted strict regulations for sludge management, including transportation, storage and disposal. The province will allocate infrastructure subsidies and special government funds, including water surcharges to fund sludge treatment. The province is also working on a

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15 Based on 22-to-30 million tons of sludge discharged annually and various sludge treatment plant project profiles; CGTI analysis
technology guide and has targeted 85% sludge treatment in South Jiangsu by the end of 2011 and 80% for North and Central Jiangsu. By 2015, Jiangsu targets a 100% treatment rate.\textsuperscript{16}

- **Guangdong** has adopted the 12th Five-Year Plan hazard-free sludge treatment targets of 80% for 2012 and 100% for 2015. In addition, the province is considering applying a RMB 0.1 to RMB 0.2/ton wastewater fee to sludge treatment.\textsuperscript{17}
- **Hebei** has strict regulations for sludge management, transportation, storage and disposal. The province plans to build a hazard-free sludge treatment infrastructure within three years.\textsuperscript{18}
- **Hubei** set up sludge treatment and pilot programs in 2011 and plans to build hazard-free sludge treatment infrastructure by 2013.\textsuperscript{19}

Efforts by Jiangsu and Guangdong to add a sludge treatment surcharge to water prices could address one of the most pressing needs for encouraging sludge treatment. In Guangdong, a provincial plan entitled Advice on Further Reinforcing Wastewater Plant Sludge Treatment and Disposal in Guangdong Province, requests a wastewater fee, including a surcharge of RMB 0.1/ton of wastewater to cover sludge treatment costs.\textsuperscript{20} In Jiangsu, the province plans to increase wastewater fees by RMB 0.1-0.2/ton.\textsuperscript{21} However, industry experts have suggested that average wastewater treatment fees would have to rise to RMB 0.4-0.6/ton to cover the cost of treating sludge.\textsuperscript{22} Thus currently proposed fees in Jiangsu and Guangdong may still be insufficient.

**Sludge Treatment Solutions and Economics**

An economic analysis shows that with high utilization and sludge treatment fees, advanced sludge treatment can be economical compared with low-cost, hazardous sludge landfilling.

The economics of sludge are as complicated as sludge itself

The economics of sludge treatment are complex because the process can involve a number of stages, including thickening, stabilization and dewatering to remove pathogens, pollutants and surplus water. Yet sludge treatment can also generate additional revenues. In CGTI’s view, this value recovery represents the future of sludge treatment, with fertilizer and biogas fuel appearing as the most

\textsuperscript{16} Jiangsu Province Government Website
\textsuperscript{22} ChinaWaterNet, “三部门明确污水处理费应包括污泥处理成本,” [Three Ministry Agreed Wastewater Treatment Fee Should Include Sludge Treatment Cost], Mar. 4, 2009; CGTI analysis
promising alternatives. Based on a sensitivity analysis of an advanced anaerobic sludge treatment plant case from Dalian, CGTI found that advanced sludge treatment plant projects may offer attractive returns with Internal Rates of Return (IRR) exceeding 30%. Capital cost, utilization, and sludge treatment fees are the most important variables.

Despite its drab name, sludge is by no means a simple substance. Sludge composition varies across wastewater discharge types, treatment process stages and geographic locations. The first step in the wastewater treatment process removes solids via mechanical screening—this is primary sludge left after screening and grit chamber processing, or from the bottom of the primary sedimentation basin. Primary sludge is an untreated, non-stabilized residual, and its composition depends on the catchment area properties. It is a thick, odoriferous fluid with a water content higher than 90%. Secondary sludge comes from removal of dissolved organic matter and nutrients, and normally takes the form of flakes of living and dead biomass and organic matter. Tertiary sludge is the remainder after activated sludge has been returned to the biological aeration basics.

Proper sludge treatment involves thickening, stabilization, dewatering and drying, but not all these steps are consistently applied in China. Stabilization reduces biochemical oxygen demand (BOD), either with aerobic or anaerobic digestion. Anaerobic digestion has lower costs and is less energy-intensive, and hence is the most used option in China. The next step, thickening, removes water in a sedimentation tank or pond; wastewater from this process requires additional treatment. Dewatering, the third stage, reduces water content to 80% via such processes as vacuum or pressure filter press, centrifuges, or drying ponds. Dewatering is a government mandated sludge treatment step in China. The last step in the process, which is rarely practiced in China, involves drying: the most common treatment type is lime drying, followed by fluidized drying beds. Thermal drying and solar drying are also options.

A range of different sludge treatment and disposal options exist

There is a range of sludge treatment and disposal methods with a variety of environmental outcomes. The most cost-effective and environmentally-friendly method is to avoid or minimize sludge discharge in the first place through high-technology wastewater treatment and re-use technologies.
There are also a number of ways to dispose of sludge that could generate revenues:

**Building materials:** Sludge can be used as a resource to produce cement, bricks or ceramic cubes, rather than being treated as a waste. However, construction materials must follow specific market requirements. Currently, sludge-derived building materials in China have yet to overcome quality barriers. The recent example of Beijing Cement’s sludge-to-cement project illustrates how technology plays an important factor in producing quality materials—the plant has been an economic failure, as discussed further below. In addition, building material processes require dry sludge, increasing initial investments and operating costs associated with dewatering and drying equipments.

**Fertilizer:** Sludge can be turned into fertilizer for agricultural or garden use. Fertilizer represents an economic way to dispose of sludge and re-use precious nutrients such as phosphorous and nitrogen. However, if treated or handled improperly, sludge-based fertilizer risks soil pollution via infiltration. Sludge must be treated fully to remove toxins and other pollutants, and industrial sludge is inappropriate for fertilizer given high heavy metal content.

**Biogas or natural gas** derived from sludge can be used by treatment plants to meet internal energy needs, thus re-using waste gases released during treatment, or selling the output to local users. If anaerobic fermentation were used to treat all 30 million tons of sewage sludge generated by China this year, in theory it could generate 2.5 billion cubic meters of methane gas, which could in turn generate approximately 4 billion kWh of electricity and reduce carbon emissions by approximately 15 million tons annually. However, the process is not without hurdles: sludge can be difficult to degrade, the process

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takes time and it requires large degradation ponds. Low organic content may affect methane releases and thus biogas volume and quality, reducing the potential for power or heat generation.\textsuperscript{24}

\textbf{Incineration} can produce district heating or electricity, and ash output can be made into bricks or activated-carbon adsorbents. Incineration has low space requirements and is sometimes considered a quick fix for China due to low cost and mature technology. However, incineration has low energy efficiency due to sludge's low calorific content and requires dry sludge, increasing pre-incineration treatment costs. In some cases incineration plant operators have been adding diesel fuel to increase sludge incineration's heat output. Furthermore, incineration raises air pollution concerns for nearby populations and is more expensive than some other treatment options.\textsuperscript{25}

\textbf{Landfilling} is in most respects the least attractive option for sludge disposal given its health and environmental impact, yet low cost and simplicity make landfilling a widespread method in China. Sludge is considered a hazardous waste. When untreated sludge is disposed in landfills, it can infiltrate soil, pollute groundwater and release methane into the atmosphere. In response, recent regulations prevent landfills from accepting sludge with water content above 60%. In addition to water and health problems caused by landfilled sludge, transporting this heavy waste to landfills creates additional costs and discards sludge content that could be re-used.\textsuperscript{26}

\begin{center}
\begin{tabular}{|l|c|c|l|}
\hline
Treatment or Disposal Method & Cost (RMB/ton sludge) & Cost (RMB/ton sewage) & Current Situation \\
\hline
Discard into Environ. & 15 & 0.01 & \begin{itemize}
\item Often used in the industry
\end{itemize}
\hline
Landfill & 40–56 & 0.03–0.03 & \begin{itemize}
\item Often used in the industry
\end{itemize}
\hline
Anaerobic digestion & 50–150 & 0.03–0.09 & \begin{itemize}
\item Quickly becoming an option
\end{itemize}
\hline
Simple compost & 70–100 & 0.04–0.06 & \begin{itemize}
\item Often used in the industry
\end{itemize}
\hline
Mechanized compost & 120–200 & 0.07–0.12 & \begin{itemize}
\item At experimental stage
\end{itemize}
\hline
Heat drying & 160–360 & 0.10–0.22 & \begin{itemize}
\item More used in large projects due to high cost
\end{itemize}
\hline
Incineration & 220–500 & 0.13–0.30 & \begin{itemize}
\item More used in large projects due to high cost
\end{itemize}
\hline
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CGTI analysis suggests advanced sludge treatment plants can be economical

CGTI analyzed data from a recently built anaerobic sludge treatment plant in Dalian, the Dalian Dongtai Xiajiahe project. The plant ranked in the 2010 Top 10 Sludge Treatment Projects according to ChinaWaterNet. It began operations in April 2009 and is operated by Dalian Dongtai Industry Waste Management Company under a build-operate-transfer (BOT) model. The plant had a 600 ton-per-day daily sludge treatment design capacity, though it now operates at roughly 25% capacity, and benefited from a RMB 135/ton sludge disposal fee, which was raised to RMB 170 starting in 2011. The plant uses anaerobic digestion to generate biogas turned into 3,000 cubic meters of natural gas per day, though at full capacity it would generate 10,000 cubic meters daily. 30% of the biogas output is used internally, and the remainder is sold to local utilities at RMB 2.4/cubic meter. On a daily basis the plant’s operations consume 70 cubic meters of drinking water, 400 cubic meters of recycled water from a nearby wastewater treatment plant, and 15,000 to 18,000 kWh of electricity. The plant costs roughly RMB 150 million, paid through a 6% 20-year loan.

Not surprisingly, low utilization has been the main factor affecting the plant’s economics. Based on a simple cash flow analysis, this study estimates the utilization rate must reach roughly 70% to make the project’s IRR economical given the sludge disposal fee level of RMB 135/ton. With a more attractive RMB 170/ton disposal fee, the required utilization rate would fall to roughly 60%, which is still far higher than the plant has experienced. A 75% utilization rate offers an IRR of 16% at the lower fee level.


illustration purposes, the figure above includes utilization levels up to 100%, but the modeled high returns are theoretical only. Several factors explain the attractiveness of this project under a high utilization scenario. First, the plant’s initial cost was low compared to other similar plants—roughly RMB 250,000 per ton per day versus RMB 412,000 for the sludge treatment facilities of the Qingdao Maidao wastewater treatment plant. Second, biogas generation reduces the plant’s electricity needs, which typically account for around 40% of operations and maintenance (O&M) costs. Third, the sludge disposal fee was increased to RMB 170/ton in 2011 to compensate for the money-losing operations during the first year of operation, under a low utilization scenario. Had the plant operated as designed, the government would never have offered such a high rate.

**Cases of project failures caution investors on the sector**

As the Dalian plant case shows, high-technology sludge treatment has the potential to be economical, but actual operations can fall far short. Three other major projects illustrate the multiple potential causes of project failure:

- **The Beijing Cement Plant Sludge Treatment Project**, though named a Top 10 sludge treatment project by China Water, is currently producing below designed capacity and running at a loss. It was intended to make sludge into cement, but the plant has been hampered by technical complexity, cement quality issues, and a difficult operating environment.  
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- **The Shanghai Shidongkou Sludge Treatment Project** was the first Chinese sludge drying and incineration project using imported technology and equipment. Beijing Golden State and Andritz of Austria won the tender and started plant operations in September 2005. In 2006, plant operators allegedly dumped untreated sludge into the river. The plant operates at less than half its design capacity. According to experts, its problems resulted from intentionally undersizing incineration design to cut costs and failure to address a high percentage of sand in sludge (22% versus the designed 3% to 4%), resulting in higher maintenance costs.  
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- **The Guangzhou Gede Sludge Treatment Project** was considered one of the world’s top projects in 2004, when it was built under a BOT contract by Guangzhou Gede to process sludge into bricks. The plant has ceased operations and is stockpiling sludge while requesting government funds to restart operations. Experts believe the plant suffered from a mismatch between design capacity versus demand, poor internal management, and equipment bottlenecks.  
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As these three projects—and the Dalian plant—demonstrate, proper capacity design and cost estimation are critical elements to project success.

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The Path Ahead

Given the rising sludge output of China’s growing municipal wastewater treatment sector, and the urgent need for a major increase in annual capital investment to meet targets, sludge treatment represents a major market opportunity. So far, inadequate levels of enforcement and the lack of a comprehensive regulatory framework have hindered market growth. Nevertheless, central-level government’s resolution to tackle the sludge issue is boosting private sector confidence. Stakeholders can take a variety of actions to accelerate the market for safe sludge treatment and disposal in China:

- **Technology providers** are already cooperating with various stakeholders to develop comprehensive water management solutions that minimize sludge discharge from wastewater treatment. In the future, providers will do more to develop low-cost solutions to generate energy or products from large or small sludge treatment plants in China. Providers can also participate in setting the process for national standards by contributing data and analysis.

- **Technology buyers** can work with solution providers at the design stage to implement comprehensive wastewater management systems, including sludge treatment. Technology buyers can do more to study best practices in China and abroad, and work with local governments to fund and execute pilot projects to promote safe sludge treatment in China.

- **Central government regulators** can do more to strengthen sludge treatment regulations and enforcement, integrate wastewater with sludge-related policies, and promote holistic policies to support the wide uses of sludge. The government can also develop detailed technology standards to promote higher efficiency and value-added sludge treatment solutions.

- **Local-level regulators** can increase local enforcement over sludge treatment and discharge, set local water prices and wastewater treatment fees considering the end-to-end costs of sludge treatment and disposal, and promote private participation in local utilities to gain outside expertise and promote long-term life-cycle cost management.
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