Converting Waste to Energy in Cities
A Case Study from China

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Outline

I. Four Propositions
II. The China Problem with sludge/biosolids
III. Key Features of the Xiangyang Project
IV. Concluding Observations
Proposition 1: Multiple stakeholders today are interested in city wastes.

- City residents
- Renewable energy protagonists
- Global commons
- Private investors

Cash flow opportunities several:
- GHG mitigation
  - Pollution control
  - Resource recovery
    - Capex subsidies, Tipping fees, Savings in round trip dumping costs
    - Payments for emission reduction
    - Revenues from Biogas, urban forestry, agriculture

Stakeholder interests vary:
- Supporters
Proposition 2: Business model requires working across sectors

- **Benefits**
  - **Environment:** recovering 96% N and 98% P
  - **Energy:** reduce GHG
  - **Reclamation:** trees cultivated by biochar
  - **Economic:** low financial cost and revenue from CNG/trees
Example closer to home: DC Water

- DC Water recently invested in a sludge-to-energy system allowing it to produce one-third of the plant’s power needs, saving about $10 million annually.
- $470 million waste to energy system, took four years to build, pays for itself, and shrinks the overall carbon footprint by one-third. The intention is to begin collecting and processing additional waste, such as restaurant kitchen wastes.
- In addition this initiative:
  - Allows plant to continue running in the event of a power failure during big storms.
  - Also expects to save an additional $2 million or so annually on treatment chemicals and $11 million annually in trucking 1200 tons of sludge a day.
- DC Water also recently issued $350M, 100-yr. municipal “century” green bond for both “grey” infrastructure (underground tunnels to hold stormwater overflows) and green infrastructure (rain gardens and bioswales). The bond issue sold out very quickly (high grade green bonds are in high demand for pension funds and other institutional investors.

Supporters
Proposition 3: Developing Country Cities can address universal public concerns with pollution

- Food Wastes are rich in Methane
- Sludge/Septage provide reliable baseload + WWTPs have land available

Waste to Energy is a viable green business with multiple local, regional and global benefits

Supporters
Proposition 4: Provided financing and contracting arrangements are suitably customized

This requires delineating accountability both within Public Organizations and among users of services by:

• Assigning Commercial, Technology and Financing Risks to parties best suited to manage them;

• Providing institutional space for entrepreneurs to innovate in terms of project design,

• Building a culture of structured learning and knowledge sharing in sectoral agencies that can be fed back to policy level, and

• Replacing projects designed in sector silos with programs aimed at value creation that leverages the willingness to pay for waste management from communities, governments and the global community.
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Chinese Explosive Growth in Urban Waste Generation is being replicated throughout the Developing World.
Consequences: An estimated 3.3 million hectares of land is polluted, most of which is in regions that produce grain.

- The Environmental Protection Ministry has estimated that 12 million tonnes of grain are polluted by heavy metals every year.
- In May 2013, it was reported that rice grown in China’s central Hunan province was contaminated with cadmium.
Illegal Dumping of Biosolids gets country wide attention

• Beijing’s illegal sludge/biosolid disposal problem first took center stage in October 2010 when local businessman He Tao was sentenced to three and a half years in prison and fined 30,000 yuan.

• Chinese Academy of Meteorological Sciences researchers concluded that this dumping had a serious environmental impact. They found that the sludge-filled gravel pits contained dangerous levels of heavy metals, ammonia nitrogen and fecal coliform. Also found was Shigella bacteria, which is a public health hazard through dysentery.

Unlike other large Asian countries, China has greatly expanded Wastewater Treatment Infrastructure.

By 2013, over 3500 wastewater treatment plants with total capacity of 150 million m$^3$ per day operated in Chinese cities.
Proper management of urban wastewater treatment plant generated biosolids has been absent in China. Major cities such as Beijing, Shanghai, Guangzhou, Hefei and others have created problems for surrounding farmlands by indiscriminate dumping of biosolids.

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Solution to the sludge problem was earlier dumping on farmlands, and today through landfills, composting and incineration.

Sludge disposal has become one of the critical works of the government with more sludge being disposed. However, landfill is the major sludge disposal method in China with a share of 57%.

(Source: MOHURD; WRI estimate)

Comparison on Sewage Sludge Disposal Methods in China (2007-2013)
Typically the situation is viewed as a Sludge Crisis, but today this could very well be an attractive PPP opportunity. Are biosolids a waste product of the city or a Resource for Society?

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The Xiangyang Waste to Energy Project

- Capacity: 300tons/day (sludge and kitchen waste co-digestion)
- Method: thermal hydrolysis + anaerobic digestion
- Product: CNG (6000m$^3$/day), biochar (55-60 tons/day) for seedling cultivation
- Operation mode: BOO with 23 years of concession period (2 years of construction period)
Production of biochar responds to public concerns with heavy metals in sludge, while creating carbon sinks through Urban Forestry.

The biochar is used for trees cultivation which brings new concept for the harmless, stabilizing disposal of sludge.
Estimates of GHG Emissions before and After the Project

Time period: 21 yrs of operation
Unit: 10,000 ton CO2e

Comparison on GHG Emission of Xiangyang Project, Incineration, and Landfill

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(Draft, Not for Distribution
Source: WRI estimate)
Financial Flows underlying Xiangyang Project Design

Xiangyang Sludge Project
300 tons/day

Government

Bank

Loan: 84 million rmb

Company investment: 30 million rmb

Loan interest: 11 million rmb/yr

Tax: 0.9 million rmb/yr

Clean energy adjustment fund: 1 rmb/m3 CNG

Sludge operation subsidy: 254 rmb/ton

Kitchen waste operation subsidy: 70 rmb/ton

Construction Subsidy: 15 million rmb

Investment: 44.7 million rmb

Investment: 89.3 million rmb

Sludge disposal plant

Pre-treatment for kitchen waste

CNG: 4.5 rmb/m3

Revenue from selling trees

Revenue from selling biochar

Investment: 30 million rmb

Company investment

Loan: 84 million rmb

Loan interest: 11 million rmb/yr

Tax: 0.9 million rmb/yr

Clean energy adjustment fund: 1 rmb/m3 CNG

Source: WRI 2015

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Drilling down on contract details

- The Private Company has been contracted in the BOO mode. It has:
  - Signed contracts with local urban construction committee (for treating sludge) and
  - local urban management bureau (for treating kitchen waste) separately.

<table>
<thead>
<tr>
<th>Capex Financing (million Rmb)</th>
<th>Investments (million rmb)</th>
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<tbody>
<tr>
<td>Company Investment 40</td>
<td>Sludge drying/disposal plant 89</td>
</tr>
<tr>
<td>Loan 80</td>
<td></td>
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<tr>
<td>Govt. Subsidy 14</td>
<td>Pre-treatment of kitchen Wastes, CNG filling station 45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operational subsidy categories</th>
<th>Amount (Rmb/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge Operation subsidy (Tipping Fee)</td>
<td>254 (including 20/ton for treating old sludge)</td>
</tr>
<tr>
<td>Kitchen waste operation subsidy (Tipping Fee)</td>
<td>72</td>
</tr>
</tbody>
</table>
Cash flow estimates

Assumptions:
1. Operational revenue on CNG and biochar occur on a daily basis as these can be sold immediately in the market.
2. Calculation of revenues of planting trees is based on the assumption that the trees will need 2 years to grow big enough to be sold to the market.

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<th></th>
<th>CNG</th>
<th>Biochar</th>
<th>Trees</th>
</tr>
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<tbody>
<tr>
<td>Operational revenues</td>
<td>90</td>
<td>20</td>
<td>400</td>
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<tr>
<td>(rmb/ton)</td>
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Key Lessons Learned

- Share best/bad practices
- Create mind-set for market-oriented design

Evidence on Markets and Energy recovery potential

Knowledge on technologies and business processes

- Contracting options
- Renewable Energy
- Energy efficiency

Policies and regulations

- Review policy frameworks
- Leverage subsidies
- Feedback lessons

Financing mechanism

- Accountability
- Green Finance

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More cities are installing or planning to construct the similar sludge-to-energy system

- Beijing
- Hefei
- Changsha
- Chengdu

5,500 tons sludge/kitchen waste treatment capacity per day = 706,000 tons CO2e reduction per year
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Proposition 5: Every city has unique characteristics but there are common elements in project design

- Develop rigorous Value-for-Money Investment Framework
- Leverage available incentives for renewable energy generation and energy efficiency enhancement
- Build on citizen led pressures to reduce air, land and water pollution to promote sustainable solutions

Decisions made at the concept and initial design stage, at the “front-end”, have the greatest influence on a project’s likelihood of success.

Beware of:

- Underestimating cost and risk factors, and overestimating expected benefits,
- Unexpected unintended negative impacts, and
- Going ahead with the project if there is uncertain investor interest

Private participation is not a resource gap filler, but a key element of the PP Partnership.
Proposition 6: Green Finance can greatly expand PPP possibilities

- Biosolids have relatively low GHG emissions and high moisture content
- Organic wastes have high GHG and moisture content.
- Perceived risks and confidence in policy regimes widen the viability gap for PPPs.

Source: A Baietti; Green Finance World Bank 2011
More Prototypes like Xiangyang in China and other countries can help develop business line

Key questions:

- Implementing long term sustainable contracts between cities, water utilities and private investors
- Separating out local and global environmental costs, so that the green finance offer only targets the latter
Post-COP 21 offers new opportunities to leverage Innovative (Green) Finance

**Principles**

- Green Finance can help off-set global externality of GHG emissions
- National and city governments off-set local externalities caused by soil and water pollution from STPs
- Funding possible if a mechanism is available to support lowest cost/ton GHG abated
- Projects should therefore support minimum amount needed to achieve financial viability

**Operational Implications**

- Establish mechanisms that self-select sectors and technologies giving ‘biggest bangs’ for each $ of public funds
- Set ceilings of support per ton of GHG abated
- Monitor transitions in order to graduate sectors and technologies
- Waste to Energy as a business line for PPPs is developed with active engagement of governments, donors and private operators

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