CREATING AN ENABLING ENVIRONMENT FOR PUBLIC–PRIVATE PARTNERSHIPS IN WASTE-TO-ENERGY PROJECTS

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EXECUTIVE SUMMARY

Asia is experiencing rapid urbanization with high population density, and there is an increasing need to better manage municipal solid waste (MSW). Many governments have realized that the potential solution is to convert waste to energy to reduce the waste volume in order to minimize the environmental and social impacts. However, waste-to-energy (WTE) requires large upfront capital investment that can be provided by public–private partnership (PPP). Such PPP arrangement also relies on many issues, making implementation complicated. As a result, the uptake of PPP for WTE has been limited across Asia.

Among the developing member countries of the Asian Development Bank (ADB), the People's Republic of China (PRC) has established many WTE plants through a PPP approach, while other countries are still at the starting point. How can other Asian countries learn from the PRC experience to set up their own WTE system? The conditions for a national PPP policy and financing arrangement in the PRC can provide some lessons for other Asian countries seeking to invest in WTE plants. Bangladesh, India, and the Philippines were selected as case studies to explore the enabling environment for WTE.

The country-specific studies on WTE development present a significant gap between the "experimental" countries (Bangladesh, India, and the Philippines) and the PRC, the benchmark country. This is due to a collision of barriers and risks that collectively "disincentivize" private sector investors and developers; impede the large-scale development of WTE; and, more importantly, hinder sustainable and integrated MSW management systems in developing Asian countries. In the PRC, incineration has become gradually recognized and accepted as an alternative solution to handling MSW. This was reviewed as a comprehensive case to illustrate what perspectives should be taken in creating a PPP for WTE systems.

This paper summarizes and augments ADB's experience in providing an enabling environment for successful private sector involvement in WTE implementation. Based on research and analysis, the study concludes that the supply chain for WTE offers a viable solution to the growing problem of managing MSW, provided that collection and treatment of solid waste is better developed. The study presents a list of screening parameters to help the potential investor evaluate a city's readiness for a potential WTE project without any country specification.

Apart from strengthening MSW management, other major barriers and risks to PPP for WTE were identified based on country-specific sector overviews. In comparing the target countries to the benchmark country, policy and regulatory gaps have to be addressed. Also, respective to each country circumstance, other barriers and risks that currently do not exist, or may not be seen as significant due to the WTE development stage each country is in, need to be considered.

WTE technology is mature and well understood in Europe and the United States and can be made available to developing countries through contractual mechanisms. However, the health and environmental impacts of poor MSW management are not yet well understood, and more awareness and knowledge sharing is needed.

The key issues revealed in the study are (i) the uncertainty of the WTE facility supply chain, including the quality or heat value of the waste collected; and (ii) the form of WTE facility capital and operational costs recovery. If these issues are addressed, a PPP for a WTE project has a good chance of becoming successful.

ABBREVIATIONS

ADB	Asian Development Bank
BOT	build–operate–transfer
DEA	Department of Economic Affairs (India)
FIT	feed-in-tariff
IEA	International Energy Agency
IIFCL	India Infrastructure Finance Company Limited
kWh	kilowatt-hour
MNRE	Ministry of New and Renewable Energy (India)
MEP	Ministry of Ecology and Environment (formerly the Ministry of Environmental Protection) (People's Republic of China)
MOF	Ministry of Finance (India and People's Republic of China)
MOHURD	Ministry of Housing and Urban–Rural Development (People's Republic of China)
MSW	municipal solid waste
MW	megawatt
NDRC	National Development and Reform Commission (People's Republic of China)
PPA	power purchase agreement
PPP	public–private partnership
PRC	People's Republic of China
RDF	refuse-derived fuel
SCA	standardized concession agreement
ULB	urban local body
UN Environment	United Nations Environment Programme
US	United States
VGF	viability gap funding
WTE	waste-to-energy

I. INTRODUCTION

As Asia continues to experience rapid urbanization with high population density, there is an increasing need to better manage municipal solid waste (MSW). One waste disposal solution is to convert waste to energy to reduce the waste volume and minimize the environmental and social impacts.

Many governments have realized the potential to use waste as energy and have started investing in this type of solution. However, waste-to-energy (WTE) needs large up-front capital investment that governments may not be able to meet.

As the demand to address rapid waste accumulation becomes more urgent, there is a need to explore public–private partnership (PPP) cooperation as an alternative to public financing for WTE infrastructure. Such an arrangement is dependent on the municipal waste management chain, energy sector, national PPP policy, and infrastructure financing, making implementation complicated. As a result, the uptake of PPP for WTE has been limited across Asia.

Among the developing member countries of the Asian Development Bank (ADB), the People's Republic of China (PRC) can be considered as an active proponent of PPP for WTE. The country has established many WTE plants through a PPP approach, while other countries are only at the starting point. How can other Asian countries replicate the PRC experience to set up their own WTE system? Tracing the waste management chain, the conditions for a national PPP policy and financing arrangement in the PRC can provide some lessons for other Asian countries seeking to invest in WTE plants.

A. Objective of the Study

ADB conducted a review of the enabling environment for a PPP in WTE projects in the PRC, as well as in Bangladesh, India, and the Philippines to identify the ideal conditions for setting up a WTE system through PPP. The study examined the MSW management chain, the institutional and regulatory policies of MSW, the use of PPP in the energy sector, and other barriers to WTE. Where appropriate, financial support and incentive policies, schemes, and programs relating to MSW management were also outlined. Based on the study, a set of strategies and solutions is presented to help countries prepare for PPP in WTE. A table listing screening parameters for investing in WTE was also developed based on the PRC experience.

B. Methodology

The study followed two methods: (i) desk review and analysis of relevant literature, which include urbanization status, policies and regulations, development plans, and project documents related to WTE; and (ii) "control versus experimental" analysis of key case studies on WTE projects. All information was gathered using publicly accessible information, and where possible for the PRC cases, through site visits and stakeholder interviews.

The bulk of the study presents a summary of each country based on the development situation and amount of available information. Analysis on factors affecting WTE follows the country situation. The control case for this study is the PRC experience, where the development of WTE facilities through PPP is applied widely. The "experimental" cases considered in this study are from Bangladesh, India, and the

Philippines since these countries only have minimal applications of PPP in WTE. These countries were also selected based on the following factors:

(i) They are among the most populated countries, both in Asia and in the world, and are undergoing rapid urbanization.

(ii) They have massive land constraints, especially in urban areas.

(iii) They are the top MSW generators in Asia and in the world (World Bank 2012) and remain underdeveloped in terms of MSW processing and disposal (United Nations Environment Programme [UN Environment] 2010; ADB 2011).

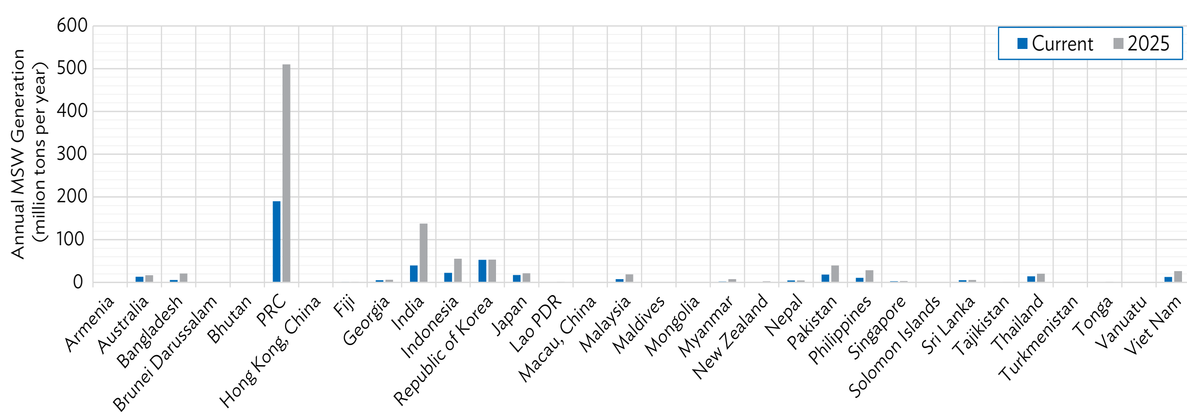
(iv) They are net energy importers (International Energy Agency [IEA] 2013; IEA 2015a; IEA 2015b; World Bank 2014) and have not realized 100% electrification (ADB 2015b; IEA 2015c; IEA 2015d).

II. MUNICIPAL SOLID WASTE AND THE NEED FOR WASTE-TO-ENERGY DUE TO URBANIZATION

A. Increasing Waste Generation and Environmental Degradation

Statistics show that the world's cities generate about 1.5 billion tons of MSW per year, of which Asia accounted for approximately 25% of the global total in 2012. This share is expected to increase to approximately 40% by 2025 due to continuing rapid urbanization. By that time, Asian cities are expected to generate around 1.8 billion tons of MSW (UN Environment 2017). In 2014, the United States (US) was the world's biggest generator of MSW at 389 million tons per year, followed by the PRC, which generates about 220 million tons of municipal waste per year (Slangen 2016; Ricardo Energy & Environment 2016; UN Environment 2010; ADB 2011). India is fast catching up, with MSW anticipated to grow from 70 million tons per year in 2014 to 140 million tons by 2025 (Figure 1). The rapid generation and huge amount of MSW is a problem that needs to be addressed.

Figure 1: Annual Municipal Solid Waste Generation in Asia and the Pacific



Lao PDR = Lao People's Democratic Republic, MSW = municipal solid waste, PRC = People's Republic of China.

Source: World Bank. 2012. *What a Waste: A Global Review of Solid Waste Management*. https://openknowledge.worldbank.org/bitstream/handle/10986/17388/68135.pdf.

MSW is not properly managed in most developing countries in Asia. Collection rates are low (60%–90%) and MSW disposal relies heavily on open dumpsites and landfills that are not adequately engineered and insufficiently sanitary (UN Environment 2010; ADB 2011). Due to improper disposal practices, the randomly disposed waste clogs bodies of water and pollutes water resources and the environment, leading to flooding. It also causes serious environmental, social, and economic issues as urbanization continues (UN Environment 2010; World Bank 2012).

In addition, MSW has low density. A standard landfill has a density of about 1 ton per cubic meter.[1] As such, conventional disposal systems (e.g., sanitary landfill or open dumpsite) require a large area, which is very valuable and not always available in dense urban settings. Landfills are also often subject to resistance from local communities due to pollution and potential health risks. Improper open dumpsites, in particular, occupy larger areas than sanitary landfills with huge environmental and social impact. Minimizing these detrimental consequences and managing waste volumes are crucial to achieve sustainable development.

B. Waste-to-Energy Development as an Option Worldwide

MSW incineration or using waste for energy provides a potential feasible solution to the above issues. It can reduce the waste volume by 90% and the weight by 80%. When implemented properly with MSW management regimes, WTE has very limited negative environmental impact. The use of WTE technologies enables the conversion of different kinds of waste into various forms of energy, serving as an added incentive to suitable and sustainable treatment of MSW. The technology can be used to generate power and reduce greenhouse gas emissions. In the US and Europe, recycling (including composting and anaerobic digestion), landfilling, and combustion are mainstream MSW management practices. Since 2010, the portion of MSW sent to landfills in the US is slightly over 50%, while approximately one-third goes to recycling and composting, and the remaining 10%–15% goes to incineration with energy recovery (US Environmental Protection Agency 2010–2014). In Europe, urban residential density is much higher than the US and land availability is limited. Therefore, the landfill rate of MSW is decreasing and waste management strategies are moving from landfill toward a combination of recycling and incineration.[2]

In Asia, where residential urban density is very high, the potential for a similar move to recycling and WTE is obvious. Because WTE plants need heavy capital investment and high professional skills for plant operation and maintenance, PPP may help to reduce the financial and technical burden on the government. It also helps to improve operational efficiency and develop sector technology, as well as manage potential risk.

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1 For example, Beijing in the PRC produced 6.7 million tons of MSW in 2015, leading to landfill occupying at least 6 million cubic meters in around a 30 square kilometer area, and it is increasing at an annual rate of 8%.

2 Increasing recycling rates and declining landfilling rates are clearly linked. Usually, landfilling declines much faster than the growth in recycling as waste management strategies mostly move from landfill toward a combination of recycling and incineration, and in some cases also mechanical–biological treatment (European Environment Agency [EEA] 2013). The rate of municipal waste landfilling for the 32 EEA member countries fell from 49% in 2004 to 34% in 2014. (Municipal waste management across European countries. https://www.eea.europa.eu/themes/waste/municipal-waste/municipal-waste-management-across-european-countries.) Landfilling decreased significantly in Europe not only because the population is denser than in the US but mainly because of the introduction of the landfill tax (http://ec.europa.eu/environment/waste/pdf/final_report_10042012.pdf). The analysis suggests that there is a relationship between higher landfill taxes (and higher total landfill charges) and lower percentages of municipal waste being sent to landfill.

C. What Is an Enabling Environment?

PPP is mainly market-driven and an enabling environment is essential to obtain and sustain the involvement of the private sector. An enabling environment is one that will help (i) reduce barriers along the MSW management chain, (ii) promote market-driven WTE development, and (iii) balance the risks shared by the private sector and the government.

Since WTE is a process of the disposal link in the MSW management chain, the top enabling condition is to ensure the chain is complete. The MSW management chain for each country in this study was reviewed, followed by a review of the policies such as the regulatory framework including government support (e.g., subsidies and preferential taxation), incineration plant performance standard, monitoring, and available financing and risk mitigation and/or allocation instruments (or gaps) to foster private sector involvement in WTE.

III. SUMMARY OF RESEARCH FINDINGS

A. Waste-to-Energy Situation per Country

The country-specific studies on WTE development present a significant gap between the "experimental" countries (Bangladesh, India, and the Philippines) and the People's Republic of China (PRC), the benchmark country. This is due to a collision of barriers and risks that collectively "disincentivizes" private sector investors and developers; impedes the large-scale development of WTE; and more importantly, hinders sustainable and integrated MSW management systems in developing Asian countries. In the PRC, incineration has become gradually recognized and accepted as an alternative solution to handling MSW. This was reviewed as a comprehensive case to illustrate what perspectives should be involved in creating a PPP for WTE systems.

1. People's Republic of China

To manage the increasing municipal waste, incineration has become an accepted solution for waste disposal. Awareness of the concept of solid waste incineration and power generation first formed in the country some 30 years ago, and pilot projects started to be implemented around 20 years ago.

In 2016, 793 million people were living in cities and towns, accounting for 57.4% of the total national population (China Statistics Year Book 2016). MSW collected in cities in 2015 exceeded 191 million tons, or 520,000 tons each day, of which 64% was landfilled and 34% (62 million tons) was incinerated for energy generation (Ministry of Housing and Urban–Rural Development [MOHURD] 2015).

By 2016, around 250 MSW incineration plants with a total treatment capacity of 85 million tons per year had been built and became operational across the country. This amounted to more than 4,880 megawatts (MW) of power generation capacity. About 80% of the plants used a PPP model to support the WTE investment. Most of the plants are in the eastern, southern, and central parts of PRC, where economic development is faster than in other areas (MOHURD 2015). In the country's 13th Five-Year Plan, the goal is to increase incinerated MSW to 54% and landfilled to 43% of the total MSW collected by 2020.

1.1 Related Policies and Regulations

Several national laws, policies, and regulations have created a favorable environment for the development and market-based operation of WTE facilities. There is evident acceleration of sector industrialization

Examples of waste-to-energy facilities in the People's Republic of China. (From left to right, top to bottom) Everbright Zhenjiang Company, Everbright Nanjing Company, Everbright Ningbo Company, Everbright Changzhou Company, China Energy Conservation and Environment Protection Group (CECEP) Chengdu Company, and CECEP Hefei Company (photos by Shengbin Liu).

alongside the rapid development of WTE. The following six policies and regulations are particularly relevant to WTE industrialization and market-based construction and operation as these have made investing in WTE attractive to private investors, especially with the help to offset WTE costs:

(i) The National Development and Reform Commission (NDRC), Ministry of Finance (MOF), Ministry of Housing and Urban–Rural Development (MOHURD), and Ministry of Ecology and Environment (MEP) jointly issued the **"Notice of Enforcing Municipal Solid Waste Treatment Tariff Mechanism to Promote Solid Waste Treatment Industrialization"** (NDRC Price Document No. 872) in 2002 (NDRC 2002b). This notice introduced the concept of a fee collection mechanism for MSW treatment with the view to promote sector industrialization. All government agencies, institutions, private sector entities, social communities, and municipal residents shall pay for MSW treatment as required. The treatment fee collected is used as service fee that helps to offset some of the cost of investment. Charging waste producers a collection fee helps ensure treatment performance and that the facilities are able to operate with financial sustainability.

(ii) **"Comments on Promoting Industrialization of Municipal Wastewater and Solid Waste Treatment"** (NDRC Investment Document No. 1591) was jointly issued by NDRC, MOHURD, and MEP in 2002 (NDRC 2002a) to complement the above-mentioned Document No. 872 across the following aspects:

- Encouraging the involvement of various types of entities in financing and operating MSW treatment facilities to accelerate "marketization" of MSW collection, transportation, treatment, and utilization.
- Setting MSW treatment tariff (tipping fee) based on the principle of marginal profit and gradual full-cost recovery.
- Encouraging the construction of MSW utilization facilities.
- Encouraging private sector to participate in financing and operating MSW treatment facilities with concession agreement period no longer than 30 years.
- Granting preferential electricity tariff to power consumption by MSW treatment.
- Local government developing management procedure and standard for quality assurance to supervise marketization of MSW treatment facilities.
- Central government leading the promotion of orderly industrialization of the sector.

(iii) **"Management Method for Concession Operation of Public Utilities"** (MOHURD Order No. 126) issued by MOHURD in 2004 is an overarching guiding document for accelerating the industrialization of WTE through PPP (MOHURD 2004). This method specifies principles, scope, and procedure of concession operation; qualification and responsibility requirements for concessionaire; procurement and execution of concession agreement; and requirements for review and supervision. Competitive bidding procedure is required for awarding the contract of concession operation. Currently, this requirement has been enforced for all built and operating WTE facilities.

(iv) **"Guidance on Creating Financing Mechanism in Major Sectors for Attracting Private Sector Investment"** (Guofa Document No. 60) (State Council 2014) specifies that investment from social communities, especially private sector, is further encouraged in areas of public services, resources and environment, biological development, and infrastructure development. Large-scale operation is encouraged to replace scattered operation of individual facilities, which will decrease capital and operational costs. Investment from social communities and PPPs are encouraged through various approaches such as concession operation, subsidies, and service purchase by government. This provides further guidance to the sector on how to operate and take advantage of the economy of scale to help defray costs of operation for the private sector.

(v) Following the issuance of the above-mentioned guidance, NDRC issued the "**Guidance on Government and Private Sector Partnership**" (NDRC Investment Document No. 2724) in December 2014 (NDRC 2014), defining responsibilities of the government in PPP project implementation, mechanism for sharing investment return and risks, and also specifying that MSW treatment is within PPP project scope and that concession operation (build–operate–transfer, build–own–operate-transfer, and build–own–operate) and service contracting models can be applied. This document also puts forward requirements for local government in PPP project implementation, including the development of healthy operation mechanism, strengthening standardized project management, and enhanced policy assurance for smooth PPP project development. This document also provides general contract guidelines for PPP projects and introduces a monthly reporting system to monitor the progress of PPP projects.

(vi) In January 2015, the State Council Office issued "**Comments on Promoting Third-Party Treatment of Environmental Pollution**" (Guoban Document No. 69) (State Council Office 2014), which specifies that service from a third party can be procured for local environmental rehabilitation and pollution treatment. This expands the scope of pollution treatment by the third party, from treatment of pollutant discharged by polluters to treatment by professional service providers. Accordingly, WTE is included in the scope of third-party environmental service and application of a PPP model is encouraged.

Application of the PPP model in municipal infrastructure has been increasingly promoted since late 2014. The central government issued multiple regulations and policies in late 2014 and early 2015 to further accelerate the application of the PPP model. The major ones include the following:

- "Management Method on Concession Operation of Municipal Infrastructure and Public Utilities" (No. 25) issued by NDRC and other five ministries and approved by the State Council, effective since 1 June 2015.
- "Guidance on Promoting Public–Private Partnership in Water Pollution Treatment" (Caijian Document [2015] No. 90) issued by MOF and MEP on 9 April 2015.
- "Notice of Developing Public–Private Partnership Projects in Municipal Infrastructure Field" (Caijian Document No. 29) issued by MOF and MEP on 13 February 2015.
- "Government Procurement Management Method for Public–Private Partnership Project" (Caiku Document No. 215) issued by MOF on 31 December 2014.

1.2 Sector Subsidies and Preferential Taxation

(i) Sector Subsidies

According to the "Notice on Improving WTE Feed-In-Tariff Policy" (NDRC Price Document No. 801) (NDRC 2012), feed-in-tariff (FIT) for WTE projects is composed of three parts: tariff applicable to coal-fired power generation, subsidy from provincial governments (flat rate of yuan [CNY] 0.10/kilowatt-hour [kWh]), and subsidy from the central government. Based on this principle, a flat rate of FIT (CNY 0.65/kWh) is set to be applicable to all grid-connected WTE projects across the country.

(ii) Preferential Taxation

As specified by the central government, preferential taxation policies for companies engaging in energy conservation and environmental protection business, including WTE, cover the following two aspects (MOF 2011):

(a) **Exemption and reduction of income tax.** Income tax is fully exempted from the first year when operation incomes are generated to the third year, and reduced by 50% from the fourth to sixth year.

(b) **Value-added tax is exempted for incomes because of tipping fees.** The practice adopted in most provinces is "refund upon collection," i.e., value-added tax is initially collected from the WTE project entity and subsequently refunded in full or half to the project entity.

1.3 Land Use

The current practice adopted in most provinces is that local governments exempt the land transfer fee payable by WTE project entities. These entities are liable only for applicable taxes that are significantly less than the land transfer fee.

Usually, WTE projects are located far away from highly populated urban areas, suburbs, and new industrial zones. This is to avoid potential conflict between facility operation and urban residents and to meet land use demand at relatively lower costs. In case the land acquisition involves resettlement of residents, local governments typically will help WTE project entities in accomplishing the required procedures, such as preparation of a resettlement plan and stakeholder consultation.

1.4 Construction and Operation

(i) Facility Development

In general, there are two types of development models for WTE in the PRC. The first one is the build–operate–transfer (BOT) contracting model, a common PPP arrangement and the mainstream model for most WTE facilities across the PRC, excluding Beijing. In the model adopted in Beijing, local district-level governments under the municipal government are responsible for developing WTE facilities within their respective jurisdictions by designating relevant government agencies as the WTE owners-cum-developers for financing, constructing, and operating the facilities.

(ii) Facility Operation

Generally, WTE project entities are locally registered with independent legal status, assuming sole responsibility for their profits or losses. They operate under concession service agreements with local governments.

A typical operational process involves (a) solid waste collection and initial sorting by local environmental sanitation administration, and transportation to project facilities; (b) waste storage in the facility after weighing; (c) treatment of leachate from solid waste storage, spraying of concentrate of treated leachate into incinerator, and transportation of wastewater to local wastewater treatment plant or reuse as cooling water; (d) electricity is generated and supplied to local grid; (e) incineration residues undergo sorting, crushing, and transportation to construction material facility as raw material or to local landfill for final disposal; (f) fume undergoes treatment by nitrogen removal before being discharged; and (g) fly ash collection through bag-type dust collector, stabilization treatment, and transportation to local sanitary landfill or local hazardous solid waste disposal center, depending upon monitoring results.

Usually, a project facility has complete operation management and quality control mechanism and procedure. Typical operation expenditures and incomes are indicated in Table 1.

Table 1: Operation Incomes and Expenditures of the Waste-to-Energy Facility

Revenue for the Facility	Major Operational Expenditures
Sale of electricity	Operational cost of incineration and power generating system
Solid waste treatment fee (tipping fee) paid by the government	Costs of treatment of fume, leachate, fly ash, and incineration residues
Other incomes which account for minor shares	Transportation cost of treated residues and fly ash
	Facility depreciation and maintenance cost
	Production management and logistics
	Financial cost, tax, and charges

Source: Authors.

(iii) Operational Cost

Operational cost is incurred mainly by incineration, power generation, pollutant treatment (fume, leachate, incineration residues, and fly ash), equipment depreciation, repair and maintenance, material, labor, and finance. However, the major components of the total operational cost are the electricity consumption of the WTE facility itself (part of the generation cost); the pollutant treatment cost due to consumption of ammonia, lime, and activated carbon powder; and financial cost. The total operational cost bears a significant impact on the financial performance of a WTE facility.

The detailed cost breakdown of a specific WTE facility is usually considered confidential by the facility management. While some operational cost data can be obtained from external sources, such as average treatment cost per ton of solid waste, the absence of other cost-related data and information makes it difficult to ascertain actual financial performance of a specific facility.

1.5 Performance Standard

(i) Power Generation

Power generation per ton of MSW incinerated is a critical operational performance indicator. It serves as a basis for determining a facility's eligibility for receiving preferential FIT dedicated to WTE (CNY 0.65/kWh). In accordance with "Notice on Improving Solid Waste Incineration Power Generation Feed-In-Tariff Policy" (NDRC Price Document [2012] No. 801), a benchmark power generation rate is 280 kWh per ton of solid waste incinerated shall apply. The rationale behind this benchmark is that a WTE plant with a monitored power generation rate higher than 280 kWh per ton of waste incinerated is considered to have co-fired the waste with fuels such as coal or oil and therefore shall not be entitled to the preferential FIT for the full amount of power generated and supplied to the grid.

Assuming an adequate supply of MSW, the major factor determining power generation rate is the quality of MSW, particularly the average calorific value and moisture content. The benchmark of 280 kWh per ton of solid waste is an estimate that was supposed to be applicable throughout the country. In fact, difference exists between actual solid waste thermal value and the value for calculation. However, in reality, there is significant variation in MSW characteristics across the country due to waste collection and segregation practice, local economic and social development, and climate conditions. Moreover, in practice, the quantity of solid waste incinerated at a WTE facility—a parameter used in calculating the monitored power generation rate (kWh/ton of waste)—is calculated based on the weight of solid waste delivered to the storage site of the WTE facility. In fact, prior to waste incineration, the moisture content of the waste at storage decreases significantly after leachate discharge, resulting in substantial increase of the calorific value of the waste. Therefore, it is power generation rates in many facilities are usually much higher than 280 kWh and in some cases even exceed 500 kWh. Many are in the range of 320–450 kWh.

The benchmark of 280 kWh/ton of waste is not being strictly enforced. In many places, the FIT subsidies are paid based on monitored power generation.

(ii) Discharge and Emissions

A set of pollutant discharge or emission indicators, such as waste gas (fume), wastewater (discharge after leachate treatment), and solid waste (incineration residues and fly ash), is applied to monitor operation performance.

In practice, fume-related indicators are often considered more critical than the wastewater and residues since the emission from the incineration plant is always a big concern. An online fume monitoring system is established and operated in all the facilities as a compulsory component. Regular monitoring parameters include dust, hydrogen chloride, sulfur dioxide, nitrogen oxide, dioxin, and odor.

Regular monitoring of treated leachate discharge is likewise conducted, with frequency ranging from twice a year to 12 times a year. Monitoring parameters include chemical oxygen demand, heavy metal, total nitrogen, ammonia nitrogen, and suspended solids. Incineration residues and fly ash are also monitored for heavy metal and dioxin. However, monitoring is irregularly conducted, as it depends on the WTE facility's specific circumstances.

Results from monitoring these parameters are reported on a regular basis to the local environmental authority and sector administration. In some facilities, online fume monitoring data is posted at the facility gate for public information. Other facilities, on the other hand, prepare a comprehensive annual environmental report for disclosure to concerned social communities.

The national standard "Pollution Control Standard for Municipal Solid Waste Incineration" (GB 18485-2014) is strictly enforced for all facilities in pollution control (MEP 2014). At some project facilities, more stringent discharge and emission standards are being implemented, such as the European Union pollutant discharge standard for solid waste incineration (DIRECTIVE-2000).

1.6 Operation Supervision

In cities with operational WTE facilities, local governments designate supervision agencies. Normally, it is either the local urban administration bureau or the municipal affairs administration of a city that functions as the supervision agency. The scope of supervision includes (i) execution of the concession agreement with specified responsibilities of the facility, service standards, and operation requirement; (ii) issuance of local WTE facility operation monitoring and evaluation measures to establish monitoring standard and issue penalties in case of noncompliance or underperformance; (iii) generating periodic reports and attending meetings; and (iv) on-site inspection and supervision of solid waste supply by the environmental sanitation agency.

In addition, the local environmental protection authority is responsible for supervision over pollutant treatment and discharge of the facility, including (i) daily monitoring and supervision through online monitoring system, (ii) annual discharge monitoring report of the facility, (iii) unscheduled on-site inspection, and (iv) regular external environmental monitoring.

1.7 Key Lessons

In summary, the main factors behind the WTE success in the PRC consist of having an adequate municipal waste supply chain, strong government policies and regulations with enforcement, access to diverse financing and government subsidies, access to advanced engineering and reliable equipment, cost-effective operation and maintenance by the private sector, stringent environmental and social compliance, and good public relations that gather community support.

2. Bangladesh

The overarching PPP policy, regulatory, and institutional framework of Bangladesh is anchored on the Policy and Strategy for Public–Private Partnership 2010 that aims to facilitate the development of core sector public infrastructure and services vital for the country's social and economic development. A series of priority sectors for PPP were identified in the strategy, including environmental, industrial, and solid waste management; water supply and distribution, sewerage and drainage, and effluent treatment plants; and power generation, transmission, distribution, and services.

The private sector plays a very important role in developing power generation capacity in Bangladesh (Khan et al. 2012). To promote private sector participation in energy development, the Government of Bangladesh issued the Private Sector Power Generation Policy of Bangladesh in 1996 (revised in 2004). According to this policy, independent power producers can implement projects using a build–own–operate modality. Favorable financing arrangements will be made possible to facilitate the equity and debt financing. Power purchase agreements (PPAs) and fuel supply agreements executed by government agencies will be guaranteed by the government. In addition, the policy provided a series of fiscal incentives (Ministry of Power, Energy and Mineral Resources 2008).

Given that a PPP framework already exists, and the private sector already plays a role in developing power generation capacity, the environment is ready for WTE investment. The national government recognizes the relevance and benefits of an incineration-based WTE facility for highly populated megacities. An annual development target plan for WTE has been established as part of the overall development plan for renewable energy in Bangladesh by 2021.

However, attempts to build a WTE plant faced a challenge, that of having a reliable MSW chain. Similar to India, the barriers to entry were the ability to collect waste and to maintain delivery of waste with high-quality heat potential, since the existing MSW chain is not strong enough to meet the demand of MSW for WTE.

In 2012, the urban population of Bangladesh was around 50 million, and the urbanization ratio was 31%. In 2010, 21.3% of Bangladesh's urban population lived below the national poverty line. The existence of poverty and slums reflect the country's messy urbanization. In addition to this, urban waste generation was around 22.4 million tons in 2012. In 2015, the gross domestic product per capita was $1,210.

Municipal authorities are responsible for the collection and disposal of solid waste. Collection efficiencies vary from 42% to 76% among various urban centers. Due to lack of proper infrastructure for waste collection, storage, and disposal, all the waste collected is dumped openly in landfills, while uncollected waste accumulates in low-lying areas and canals. This rather unorganized waste collection and storage system underscores the country's lack of a sufficient supply of waste that is crucial to make the WTE process work.

Currently, there are no WTE projects based on MSW incineration or gasification in Bangladesh, just as there are no existing programs or schemes designed to support WTE. (Climate Action 2015; Mittal

2015; Rasel 2015; Singha 2015; GIZ 2016). In 2012, Dhaka North City Corporation and Dhaka South City Corporation announced plans to build an incineration-based WTE plant in Matuail and an anaerobic digestion plant in Aminbazar. The plants were planned to have a combined capacity to process 1,000 tons of waste and produce 10 MW of power upon commissioning (Alam 2012). Despite the successful bidding process, construction of the plants was delayed several times and eventually did not start (Mahmud 2014). A critical reason was the challenge of developing processes for waste collection (SREDA 2015). A WTE plant would need consistent waste stream to feed the incineration.

There is a lack of FITs for grid-connected renewable energy in Bangladesh. Although the Draft Feed-In-Tariff Regulations were issued by the Bangladesh Energy Regulatory Commission in 2015, these regulations are applicable specifically to wind power, utility scale solar photovoltaic, solar rooftop photovoltaic, and other small solar power projects (Bangladesh Energy Regulatory Commission 2015). Other renewable energy technologies such as WTE are not covered by these regulations. Moreover, there is no standardized PPA for renewable energy in Bangladesh (SREDA 2015).

3. India

India has some experiences with WTE but success is limited because PPP for WTE has not been fully explored. A National Public–Private Partnership Policy was published by the Department of Economic Affairs (DEA), Ministry of Finance (MOF) in 2011 to serve as a broad framework outlining the fundamental governing principles for implementing PPP projects across diverse sectors (DEA MOF 2009, 2010, and 2011). It also articulates a streamlined PPP process consisting of four phases: PPP identification, development, procurement, and PPP contract management and monitoring.

In addition, an overall framework for PPP agreement options in the context of integrated MSW management was developed, encompassing collection, segregation, storage, transportation, processing, and disposal. Under this framework, three PPP agreement options were defined based on MSW functions and who best could perform it: (i) functions that could be best performed by municipal authorities only, (ii) functions that could be performed by municipal authorities and/or private sector, and (iii) functions that could be best performed by the private sector only.

This MSW policy and regulatory framework was established through a series of policy interventions and financing initiatives. The pivotal principle of MSW policies was provided by a framework for MSW management in urban areas of India, established through the notification of the Municipal Solid Waste (Management and Handling) Rules 2000 under the Environment Protection Act 1986, released by the Ministry of Environment and Forest. Other major policies and initiatives include, among others, the Bio-medical Waste Rules (1998); the development of a Technical Manual on Municipal Solid Waste Management (2000); the setup of a Technology Advisory Group on Municipal Solid Waste Management (2000); the Inter-Ministerial Task Force on Integrated Plant Nutrient Management (2006); National Urban Sanitation Policy (2008); the permissions for issue of tax-free bonds by urban local bodies (ULBs); income tax relief to waste management agencies; guidelines for private sector participation; introduction of commercial accounting system in ULBs and other such sector reforms; development of model municipal bylaws; and provision of financial assistance under various packages and schemes, including the 12th and 13th Finance Commission grants, the Jawaharlal Nehru National Urban Renewal Mission, and the Urban Infrastructure Development Scheme for Small and Medium Towns.

However, in 2012, the nationwide compliance rates of MSW Rules 2000 were found to be low, particularly in terms of disposal. In many cities, collection and disposal of residential wastes represent a significant portion of the budget. In a ULB, about 60%–70% of the budgeted amount for solid waste management works is spent on street sweeping or waste collection, 20%–30% on transportation, and less than 5% on final disposal of waste. Many municipalities have not yet identified sanitary landfill sites, and in several municipalities, the existing dumping grounds are already full and the huge piles of solid waste pose threats to human and environmental health.

In terms of waste collection, the framework set out for MSW is also still not enough. In 2015, India had an urban population of 430 million and an urbanization rate of 33%. In some places, the urban population density was very high; in Delhi, for example, there were more than 11,300 people per square kilometer. Given this amount of people, according to India's Central Pollution Control Board Annual Report 2015–2016, a total of 135,200 tons of MSW were generated daily in the country's urban areas. This amount did not include waste picked up by household waste collectors and rag pickers on the streets. However, only 111,000 tons or 82% of the waste was collected per day, and of this, only 23% was treated by municipal authorities—or as low as 19% in terms of the total MSW generated daily. The remaining waste, about 81%, was disposed untreated at dump sites or landfill sites, or simply littered.

To date, the regulatory and policy environment for MSW has not advanced and there is a need for the government to have a closer analysis and to take measures to create the necessary enabling environment to improve waste disposal and harness this waste as an energy source.

The involvement and role of private sector in MSW management has been growing in India over the past 2 decades. Initial attempts at large-scale private sector participation were made around the mid-1990s in few cities, such as Chennai and Hyderabad, with the aim of achieving operational efficiency through the private sector's managerial capability. Private sector participation, however, was limited to specific components of road sweeping, collection, and transportation as part of the entire MSW management value chain. Since the late 1990s, the ULBs gradually realized the importance of processing and recycling MSW to reduce the amount disposed to landfills. Private entities were engaged in many cities across the country for development, operation, and maintenance of MSW processing facilities, most of which were composting projects.

For MSW processing and disposal, given the constraint of financial resources, institutional weakness, and lack of technical expertise and capabilities that municipal authorities are confronted with, the framework has identified the necessity and significance of introducing a PPP approach in setting up waste processing facilities. This includes WTE projects to generate power from the segregated high calorific value combustible waste or refuse-derived fuel (RDF); set up compost plants or biomethanation plants to process biodegradable fraction of MSW; set up construction and demolition waste processing plants to make bricks, paver blocks, etc.; and set up sanitary landfills for safe disposal of waste. In this context, WTE has been defined to consist mainly of incineration, gasification, and pyrolysis. A minimum plant capacity of about 300 tons of segregated combustible waste per day or about 300 tons of RDF per day has been identified as the threshold to make WTE facilities adopting these technologies financially viable and sustainable.

The Ministry of New and Renewable Energy (MNRE) developed and launched a scheme on WTE in 2007, with the main objectives of (i) setting up five pilot WTE projects through PPP and (ii) creating conducive conditions and environment, with fiscal and financial support, to develop and demonstrate WTE.[3] The scheme was implemented from 2007 to 2015, with yearly progress achieved and reported. The MNRE's latest progress report for 2015–2016 showed that a new 12-megawatt (MW) grid-connected WTE facility and 0.5 MW off-grid or captive WTE plant were installed during the year (MNRE 2016),

[3] The five pilot WTE projects are Timanpur–Okhla Waste Management Private Ltd. in Okhla, Delhi; East Delhi Waste Processing Company Ltd. in Gazipur, Delhi; Srinivasa Gayithi Resources Recovery Limited in Bangalore; RDF Power Projects Ltd. in Hyderabad; and Rochem Separation Systems (India) Pvt. Ltd. in Pune.

increasing the cumulative installed capacity of WTE (including those from industrial waste) to 273.59 MW. However, according to Energy Statistics 2015, the estimated total potential of WTE was 2,556 MW, inclusive of 1,022 MW from industrial waste and 1,534 MW from municipal waste (Central Statistics Office 2015) (MNRE 2014). Clearly, there exists a significant gap in untapped potential that needs to be explored.

Waste with low heat value. In South Asia, some waste-to-energy plants lack sustainable supply of municipal waste, such that waste seen here included trash from an old dump site (background), which has lower heat value, unlike "fresh" waste (foreground) that have higher heat value (photo by Anand K Jalakam).

Initiatives to introduce processing and disposal technologies to the MSW management chain in India can be traced back to the 1980s, but almost all of the WTE projects have not operated to their designed capacities, leading to the termination of operations or closure of the facilities.[4] By 2010, Timarpur, Hyderabad, and Vijayawada had the only three WTE projects in India, and not all of them were operational (Annepu 2012) (Planning Commission 2014).

In 2016, the Jabalpur WTE plant was successfully commissioned as a flagship WTE facility in Madhya Pradesh (Jabalpur Smart City Limited 2018). The project was awarded to Essel Infraprojects Limited, which set up the plant to process 600 tons of municipal solid waste per day using a build–operate–

[4] These WTE projects included the Timarpur MSW incineration project established in 1987, Hyderabad refuse-derived fuel (RDF) WTE project in 1999 (RDF plant in 1999 and power plant in 2003), Vijayawada RDF WTE project in 2003, and also a couple of biomethanation plants.

transfer (BOT) modality with 20-year concession. Daily collection and transportation of the MSW is operated by the Jabalpur Municipal Corporation. The plant is fully functional, generating 11.5 MW electricity, which is enough for 18,000 households. Through the reduced volume of solid waste, more than 4 hectares of land can be saved annually (Taneja and Paranjpe 2017).

Takeaways from past experiences were summarized as: (i) no sustainable supply of committed municipal waste in terms of quantity and quality; (ii) low heat value due to presence of construction and demolition waste, which made WTE operations difficult and more expensive; (iii) the WTE equipment was not properly designed to handle the MSW in India; and (iv) lack of proper due diligence from private investors and financial viability.

4. Philippines

In 1990, the Government of the Philippines enacted Republic Act 6957, "An Act Authorizing the Financing, Construction, Operation, and Maintenance of Infrastructure Projects by the Private Sector, and for other Purposes," also known as the BOT Law to provide legal framework for PPP infrastructure development, primarily through BOT and build-transfer arrangements. Amendments to the BOT Law were introduced in 1994 to broaden the list of PPP government implementing agencies, provide incentives for attracting private sector investments, and include other contractual arrangements or schemes to implement PPP projects.

Under the BOT Law and its 2012 Revised Implementing Rules and Regulations, the principal contractual arrangements for PPPs in the Philippines include BOT, build–transfer, build–lease–transfer, build–own–operate, build–transfer–operate, contract–add–operate, develop–operate–transfer, rehabilitate–operate–transfer, and rehabilitate–own–operate. Other forms of contractual arrangements may also qualify as a PPP under the BOT Law provided that the authority approves such arrangement.

A wide range of project types across different sectors is eligible to be implemented through PPP contractual arrangements. MSW-related facilities and climate change mitigation infrastructure projects are included. As of April 2018, the Quezon City Waste-to-Energy Project is the only MSW-related project being developed through PPP. The project is currently under negotiation (PPP Center 2018).

In 2015, the Philippines had an urban population of 45.2 million, an urbanization rate of 44.4%, and a gross domestic product of $2,878 per capita. The projected MSW generation rate was 15 million tons per year, including 3.75 million tons from Metro Manila. Nationwide, only 40%–85% of generated MSW is collected, implying that 15%–60% is improperly disposed of or littered. For Metro Manila, the collection rate is at 85% (Castillo and Otoma 2013).

Currently, one WTE facility is operational in the Philippines: the Payatas Controlled Waste Disposal Facility in Quezon City, Metro Manila. The electricity generated from the facility is being sold to the Manila Electric Company to supply power to nearby communities. The first Biogas Emission Reduction Project is developed and operated through PPP by Pangea Green Energy Philippines, which has its main office in Italy. The facility commenced development and operation in 2008. To maximize the WTE generation capacity of the Payatas facility, the Quezon City local government on December 2016 passed a city council resolution giving authority to the city mayor to forge a PPP agreement for the development of a new WTE facility also in Payatas.

MSW incineration is banned by several Republic Acts: Republic Act No. 8749 (Clean Air Act of 1999), Republic Act No. 9003 (Ecological Solid Waste Management Act of 2000), and Republic Act No. 9513 (Renewable Energy Act of 2008). The ban on incineration under Republic Act No. 8749 has some ambiguity due to its wording. It could mean either a totally unconditional ban on incineration regardless of technology specifications and emission standards, or a conditional ban that applies only to incineration that emits poisonous and toxic fumes exceeding the stipulated limits.

Table 2 summarizes the urban MSW in the target countries in comparison with the situation of the PRC. Data from the US is also included to provide a point of contrast between developing and developed countries.

Table 2: Overview of Urban and Municipal Solid Waste per Country

Country	PRC	Bangladesh	India	Philippines	US
GDP in 2015 ($/per capital)	8,069	1,210	1,613	2,878	56,207
Urban population (million in 2015)	779	50	430	45	260
Urban population ratio	55.8%	31%	33%	44.4%	81.7%
Total MSW produced in urban area (ton/day)	520,000	61,400	188,500	30,000	707,000
MW production (kilogram/ person day)	0.7-1.0	0.4	0.4-0.6	0.5-0.7	2.0
Heat value	280 kWh/ton	...	...	...	...
MSW collection ratio		37%	82%	40-85%	...
Standardized MSW	Collection transport and disposal by local government	...	...	Collection transport and disposal by local government	Local government auction off waste collection and transport to private companies
Disposal	64% landfilled and 34% incineration	...	Random disposal and open dumpsite	Mainly in open dump sites	12.8% combustion with energy recovery and 52.6% landfilled, recycling and composting 34.6% (in 2014)
Tipping fee ($/ton)	5-30	...	...	...	Around 100
Feed-in-tariff	0.65 CNY/kWh for 280 kWh per ton of MSW (from 2012)	...	...	...	...
Current WTE plants	250 plants with capacity of 85 million tons per year by 2016	...	None	...	86 plants with capacity of 28 million tons per year by 2016
Electricity generated	4,880 MW/year	...	...	...	2,720 MW/year
WTE through PPP	Around 200 are operated by private sector (80%)	...	...	...	77 are operated by private sector (90%)

CNY = Chinese yuan, GDP = gross domestic product, kWh = kilowatt-hour, MSW = municipal solid waste, MW = megawatt, N/A = not applicable, PRC = People's Republic of China, US = United States, WTE = waste-to-energy.

Note: MSW includes residential waste (including waste from multi-family housing) and waste from commercial and institutional locations, such as businesses, schools and hospitals. (United States Environmental Protection Agency)

Source: Authors; China Statistics Year Book 2015; India Statistical Year Book 2015; United States Environmental Protection Agency 2015.

B. Analysis of Readiness for Public–Private Partnerships in Waste-to Energy in Different Countries

The country-specific studies on WTE development in the preceding section clearly present a significant gap between the target countries (Bangladesh, India, and the Philippines) and the PRC (as reference country for benchmarking). This is a collision of barriers and risks that collectively cause challenges that disincentivize private sector investors and developers and impede the large-scale development of WTE. More importantly, sustainable and integrated MSW management systems in the target countries are missing and countries would first need to look at implementing policies and regulations that can help to foster MSW management, and thus facilitate PPPs for WTE. They can look to the PRC example to identify ways to create the right incentive to improve MSW management and develop a conducive environment for PPP in WTE to develop and grow.

Apart from strengthening MSW management, other major barriers and risks to PPP for WTE were identified based on country-specific sector overviews. In comparing the target countries to the benchmark country, policy and regulatory gaps have to be addressed. Also, respective to each country circumstance, other barriers and risks that currently do not exist, or may not be seen as significant due to the WTE development stage each country is in, need to be considered. These barriers and risks can be grouped into the following areas: MSW-related, policy and financing, WTE technology, and other factors.

First, as previously stressed, all the countries under the study still lack the efficiency of a proper MSW management. The collection of waste, its storage, and delivery to the potential WTE site are weak. The quality and quantity of waste also matters, as WTE requires consistent and high-quality wastes that can go into the plant for energy generation. Additionally, the waste needs to be able to generate enough energy without needing extra fuel source to incinerate it. All the countries reviewed could use improvement in MSW management, focusing on reliable solid waste collection and delivery to the WTE site.

Second, to reduce barriers and risks relating to policy and financing, governments can develop and enact policies that support PPP for WTE such as a policy on tipping fees, revise or develop renewable energy sector policies, and develop PPP concession agreements. Governments can also provide some financial support to fill viability gap funding (VGF), provide incentives through taxation policy to help PPP for WTE, and make access to low-cost debt financing available so that businesses can enter the market.

Third, gaps in technology for WTE still exist and countries can explore further collaboration with the private sector to invest in incineration technology maturity and appropriateness, power generation rate (kWh/ton of MSW), pollution discharge and emissions, and development and operation monitoring and supervisions. These features can be achieved by providing incentives to the private sector to conduct more research and development or governments can bring together key agents in WTE and facilitate learning across countries and companies.

Fourth, other barriers to consider include how countries plan land use and how to best allocate scarce land in urban areas. Increasing waste requires a larger amount of space for disposal, but this can be addressed by diverting waste to WTE plants. On the other hand, allotting land for WTE facilities also contend with opposition from some communities, as this poses the same “not in my backyard” thinking that landfill arrangements face. Engaging with stakeholders through public consultations can help to facilitate understanding among communities about the advantages of WTE and can even generate support for the project once the public knows all the constraints and barriers to better waste management.

There are also barrier variations that are unique to each country, and an example of this is in the Philippines, where incineration is banned, and in Bangladesh where no WTE project has been put into operation despite the government's decision to promote WTE and its issuance of relevant plans and supporting policies. However, such problems are common when sector development progresses to a certain level. One of the most typical examples is the tipping fee, which has been found to be a critical issue for WTE facilities in India.

C. Possible Solutions to Eliminate Barriers to Waste-to-Energy Development

Based on the PRC's experience, international best practices, and WTE development in target countries, analysis was done on how to address the barriers in the waste sector, in policy and financing, WTE technology, and other issues, to encourage PPP in WTE.

1. Municipal Solid Waste Sector Policies

1.1 Waste Management Chain

MSW sector policies should clearly define different waste processing and disposal options, such as anaerobic digestion, landfill, and composting, in the overall context of developing an integrated and sustainable MSW management system. Ambiguity and inconsistency that leads to an open interpretation of WTE's role needs to be avoided. The ban on incineration in the Philippines is an example.

If governments choose to prioritize WTE as the preferred processing and disposal option and promote its development through PPP, a strong and clear enabling policy framework is needed. This entails formulating plans and policies in favor of WTE, including government subsidies, feed-in-tariffs (FITs), tipping fees, and preferential taxation. This would collectively create an attractive investment climate for private developers, particularly commercial financing institutions.

In parallel, given the relatively higher costs of WTE compared with other waste management options, it is useful to disincentivize competing options that are normally less expensive in the short term but costly in the long term, such as anaerobic digestion and landfill-gas utilization. For example, landfill tax can be introduced to increase the costs of disposing of waste to landfill sites, therefore increasing the bankability of WTE. In addition, it is important that illegally operated dumpsites commonly found in Bangladesh, India, and the Philippines be closed with the help of stricter law enforcement.

1.2 PPP Concession Arrangements

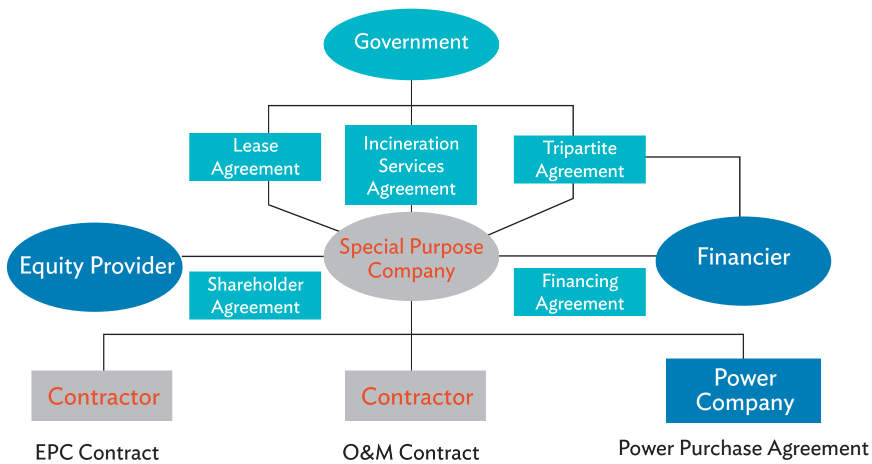
Bangladesh, India, and the Philippines all have well-established PPP policy, regulatory, and institutional frameworks, and have extensive experience of using PPPs to develop municipal infrastructure and deliver public services across a wide range of sectors. However, Bangladesh and the Philippines have almost no experience in PPP-based WTE and India has very limited experience from previous WTE projects.

Contracting models. Build–operate–transfer (BOT) is the main contracting model for PPP concession arrangements for WTE in the PRC, and it has proven to be feasible and efficient. The typical concession period is 25–30 years, excluding construction, with possible extensions subject to renegotiation. Technically, variants of BOT, such as build–own–operate–transfer, build–own–operate, design–build–own–operate–transfer, and design–build–finance–operate–transfer, are also feasible models for WTE as demonstrated in developed countries.

The PRC's private sector participation in BOT is still limited to WTE. The upstream municipal waste collection and transport remains largely the local government's responsibility. With recent logistics technology development, the private sector has the potential to expand the scope of their work upstream (e.g., waste collection, waste treatment fee collection and transport). Such model can be more helpful for countries with limited local government capacity.

Figure 2 shows a typical BOT or design–build–own–operate model for WTE projects that was successfully used in Singapore. It is noteworthy that a tripartite agreement between the government, WTE company or service provider, and the investor is included in the PPP arrangement. It allows the investor to reserve the right to step in and take over the plant in the event of default by the project company. The tripartite agreement also allows the government to step in if it does not have confidence in the project company's ability to operate properly and service its debt. While such a tripartite agreement is not common in WTE projects in the PRC, it is considered a recommended risk-mitigation approach for Bangladesh and India, where financiers are generally risk-averse and are reluctant to make loans to finance WTE projects.

Figure 2: Typical Build–Operate–Transfer or Design–Build–Own–Operate Structure for Waste-to-Energy Projects



EPC = engineering, procurement, and construction, O&M = operation and maintenance.

Source: Adapted from Keppel Integrated Engineering (2012) and Tuan (2016).

Standardized concession agreement. The PRC has no standardized concession agreement (SCA). However, given that the WTE sector in the PRC has already achieved a considerable level of industrialization, the actual concession agreements executed for WTE projects in different provinces do not differ significantly and key terms and conditions are highly similar.

In the target countries, to address the risks and uncertainties associated with contractual performance on the part of both parties (government and WTE company), a WTE-specific SCA developed and adopted by the authorities is strongly recommended for the specific purpose of regulating and promoting WTE development at an early stage. Moreover, from a financing perspective, it is expected that a signed SCA can assist the private entity in raising capital from investors (i.e., commercial banks) to reach financial closure of the awarded WTE project.

Based on the PRC experience, the recommended SCA for the target countries should clearly specify the rights and obligations of both parties, with provisions reflecting reasonable levels of flexibility for the private entity to develop and manage the plant to conform with specific local requirements and conditions. Regular monitoring should be undertaken by the government in terms of enforcing relevant provisions. Key elements of the SCA should include

(i) adherence to MSW- and renewable energy-related policies and rules;

(ii) government financial support scheme (e.g., viability gap financing or VGF);

(iii) key performance indicators and threshold, where appropriate;

(iv) incentives and penalties;

(v) risk allocation between both parties;

(vi) monitoring and inspection mechanisms;

(vii) remedy measures to address default events; and

(viii) suspension or termination for breach of agreement.

Preparedness for public–private partnership procurement process. PPPs should provide a transparent risk-sharing arrangement among the parties involved. The general principle is that project risks are allocated to the most cost-effective party. For example, political and regulatory risks are more appropriate to the public sector, while the private sector takes construction and operation risks. The allocation of commercial risks depends on expected demand for services produced by the project and the predictability of costs and revenues.

The government, as a party to the PPP agreement, should make efforts to ensure preparedness during the pre-bidding phase. This may include standardized documents (request for qualification, request for proposal, SCA), selection of appropriate project site, land procurement arrangements, project appraisals, detailed technical studies, financial and risk analysis, necessary statutory and regulatory approvals, permits, and clearances. A readiness mechanism will help streamline and facilitate the bidding process.

1.3 Land Use

Given the nature of MSW treatment processes, governments should implement preferential policies for land use of WTE facilities. While it is understood that land-related policies are normally complex and influenced by economic, social, and even political factors, successful experience in the PRC is of value and can be drawn on for WTE facilities elsewhere. In the PRC, land transfer fees are exempted and project developers are only liable for applicable taxes and charges that are significantly less than land transfer fees, which significantly help bring down the overall cost of project development.

Additionally, if land acquisition involves resettlement of people, local governments should help project developers in accomplishing the required procedures, such as preparation of resettlement plans and conducting stakeholder consultations.

1.4 Waste Reduction Strategy

It is important to incorporate changing consumption and purchasing habits into an integrated solid waste management plan to reduce and recover waste. Proper segregation of MSW increases the recovery of materials and energy from the waste stream. Government policies should also minimize competition between recycling and WTE; for instance, by providing clear guidelines for materials that are not suitable for recycling because of contamination, pollutants or other toxic substances, cost, etc. Measures should also be taken to increase consumers' confidence in recycled products (i.e., no hazardous substances or questionable environmental and social practices).

1.5 Stakeholder Consultation and Public Relations Management

Just as significant for any WTE endeavor is ensuring that WTE project developers undertake adequate public consultation during the project preparation stage. This is best done under supervision and with support from local government agencies.

Engaging the public and other stakeholders can take various forms, such as information disclosure through public media, interviews with affected households, questionnaire surveys, and workshops.

Depending upon the specific project conditions, external expertise may be needed by WTE project developers to provide advice and assistance in addressing highly sensitive issues that can have major social impacts and are likely to put the project construction and operations at risk. Typical sensitive issues include land acquisition, resettlement of residents, and compensation.

The PRC's experience shows that at the operations stage, public consultation and relations management was generally overlooked, and at most undertaken by the facilities on a case-by-case basis when serious issues occurred. To a large extent, this was because usually there were no mandatory requirements on stakeholder consultation and public relations in local regulations or in management directives. Lack of clarity in demarcation of responsibilities between WTE facilities and local government agencies is also a contributing factor. For Bangladesh, India, and the Philippines, this is an issue that governments should consider when formulating sector development plans and developing relevant regulations and methods.

2. Waste-to-Energy Project Design

2.1 Waste Quantity and Quality

Accurately predicting MSW quantity and quality is crucial for designing a WTE plant. Waste quantity and quality delivered is essential to the plant's stable and sustained operation at the desired performance standard. Often, a major factor causing underperformance or even ultimate failure of WTE projects is the lower-than-required amount of MSW supply, and the considerable mismatch between the required physical and chemical properties of waste feedstock as integral part of technical specifications of WTE boilers and the actual conditions of MSW inherently characterized by being heterogeneous. The high moisture content, large amounts of noncombustible waste products such as construction wastes, and high ash content, aggravated by insufficient segregation and pre-treatment either prior to waste delivery or upon delivery to project site, result in low calorific value of waste. This compromised combustion efficiency could cause boilers and auxiliary equipment, like filters, to malfunction.

The "take-or-pay" payment structure in a PPP agreement is a solution, as demonstrated in the PRC, Singapore, and other countries. It requires the government to pay up to 100% of treatment costs calculated based on full incineration capacity and a negotiated tipping fee, regardless of the actual quality of waste delivered and the resultant actual utilization rate of the facility. This way, the private developer has a lesser risk exposure to waste supply. However, it is unusual for the government to guarantee waste quality in such an agreement as waste characteristics are affected by many upstream factors beyond the control of local government. Therefore, the private developer must conduct adequate due diligence prior to bidding and negotiations and has to bear the risk of waste quality fluctuation and its impact on incineration and power-generation performance.

2.2 Incineration Technology Maturity and Appropriateness

For demonstration projects and early-stage sector development, mature incineration technologies with proven viability in the Asian region and with relatively lower costs are suggested for Bangladesh, India, and the Philippines. Moving-grate incinerators should be prioritized over fluidized-bed or rotary-kiln technologies. Gasification and pyrolysis are not recommended due to higher costs and far less applications than incineration. The same principle applies to fume and leachate treatment as integral parts of a WTE facility. Such practice helps ensure project affordability, technical performance, and environmental and economic benefits at project level, establishing sector benchmarks for larger-scale deployment.

However, given that technologies need be imported, certain changes to plant design and operations might be necessary to ensure adaptability and flexibility in operations under local conditions. Due to cost implications, this requires both the government and private developers to conduct adequate due diligence at the feasibility stage.

2.3 Pollutant Discharges and Emissions

Pollutant discharges and emissions are important indicators of WTE operational performance. Key components include fumes, leachate, wastewater discharged after leachate treatment, incineration residues, and fly ash. As part of a WTE facility, it is compulsory that an online exhaust-fume monitoring system be established and operational. Parameters for regular monitoring include dust, hydrogen chloride, sulfur dioxide, nitrogen oxide, dioxin, and odor. For leachate, regular monitoring of chemical oxygen demand, heavy metals, total nitrogen, ammonia nitrogen, and suspended solids should be conducted for discharge of treated leachate at reasonable frequencies. Incineration residues and fly ash need to be monitored for heavy metals and dioxin on a regular basis as well. Final disposal of incineration residues and fly ash need to be tracked. All monitoring results should be reported to the local environmental authority and the sector administrative body on a regular basis.

The requirements on control over pollutant discharges and emissions from individual WTE facilities may vary a lot depending upon local environmental standards. More stringent requirements will drive up the costs of pollutant treatment (consumption of ammonia, lime, and activated carbon powder) substantially, presenting greater challenges to a facility's financial viability and attractiveness to private investors. Hence, this is an important aspect to consider during negotiations on key revenue-related terms and conditions of a concession agreement.

2.4 Project Development and Operation Supervision

WTE facility development and operation supervision by either national or local governments, or both, is important for achieving the expected demonstration impact of pilot WTE projects at a very early stage of sector development. Its importance increases when the sector scales up and further develops toward industrialization, which requires sector-wide administration and regulation. The scope of supervision should cover the following key aspects:

(i) execution of concessional agreements in which responsibilities of facilities, service standards, and operational requirements are specified;

(ii) issuance of local WTE facility operational monitoring and evaluation measures to establish monitoring standards, quality, and procedures, as well as penalties, in event of noncompliance or underperformance;

(iii) pollutant treatment and discharge (online monitoring system, monthly and/or annual reports);

(iv) on-site inspection, both scheduled and unscheduled;

(v) supervisory meetings attended by project facility representatives;

(vi) periodic operational reports on the facility; and

(vii) solid waste supply by the environmental sanitation agency.

3. Financial and Economic Viability

3.1 Power Generation Rate and Renewable Energy Sector Policies

Banks and financial institutions conduct detailed due diligence on WTE projects to assess the predictability of project costs and revenue streams. Major revenues are those from selling electricity to the power grid and tipping fees charged for unloading waste at a WTE facility for treatment.

The target countries may consider to either define a flat preferential FIT for the entire WTE sector—a practice adopted in the PRC—or approve project-specific FITs. In the event of the latter, it is essential that the FIT be appropriately structured and determined in the power purchase agreement (PPA) between a WTE project developer and the power grid operator to ensure sustained project financial viability throughout the concession period. The PPA should contain provisions for certain mechanisms or arrangements allowing for revisiting and revising the tariff to address the risks and uncertainties associated with a sharp increase of operational expenses.

In addition, it is suggested that the "must-run" status in favor of renewable energy projects should be granted to WTE. Enforcing a minimum percentage for purchase of power generated from renewable energy sources by power grids will also indirectly benefit WTE. Examples include renewable portfolio standard and renewable purchase obligations.

It is not recommended to introduce a benchmark power generation rate (kWh/ton) in Bangladesh, India, and the Philippines that will be used to determine a WTE facility's eligibility for preferential FIT. The practice in the PRC in this regard is not considered relevant or necessary in the context of the target countries, and, besides, enforcement in the PRC is inconsistent. To incentivize potential private investors and promote sector development, WTE facilities should not be penalized for co-firing coal or oil with MSW to generate more power, if pollutant discharges and emissions comply within acceptable environmental standards and limits.

3.2 Tipping Fee

The tipping fee is the fee charged for unloading waste at a WTE facility for treatment, structured to bridge the financial gap between the costs shouldered by the private concessionaire and the income derived from selling electricity to the grid to enable viable implementation of the project.

In India, to enable the healthy development of PPP-based WTE, the current practice of some urban local bodies (ULBs) and municipal authorities of charging royalty payments from the private concessionaire, instead of paying a tipping fee, should be terminated. In developing countries, there is also the possibility that the government entity, as contracting authority, does not duly fulfill the obligations of a tipping fee. As a potential arrangement of payment guarantee and security in favor of the private concessionaire, an escrow or imprest account mechanism could be set up to ensure timely payment of the tipping fee to the private concessionaire.

Some good practices on engaging households to shoulder waste treatment fees in the water sector can be applied to help offset the tipping fee for WTE. For example, waste treatment fees are often collected together with water tariffs by water distribution companies, who then pass the aggregate fees to the local governments. This partially helps alleviate the local governments' financial burden and lighten the tipping fees for WTE.

3.3 Taxation Incentives

Decreased tax liabilities can improve project cash flows substantially. The existing preferential taxation policies for promoting MSW management and renewable energy in Bangladesh, India, and Philippines should also be consistently applicable to WTE development. Additional incentives may include exemptions or rebates of value-added tax, accelerated depreciation, etc.

3.4 Government Financial Support: Viability Gap Funding

To promote early stage WTE development in Bangladesh and India, it is suggested that the existing viability gap funding (VGF) support limits of 30% (in Bangladesh) or 20% (in India) of a PPP-based project's capital expenditure be raised to 40% in favor of PPP-based WTE projects. The VGF support will be used as a key parameter in the competitive bidding process, in which the private developer bidding for the lowest VGF will be ranked most favorably. A portion of the total VGF offered to a WTE project could be structured to be disbursed based on actual operational and contractual performance. This will not only ensure the private developer's commitment to project operation and maintenance, but also help alleviate the tipping fee burden shouldered by the government. Over time, the initial grant-based capital support should be gradually phased out and replaced with performance- and outcome-based subsidy support. It is suggested the same approach be taken in the Philippines, if and when the incineration ban is lifted, and the government decides to promote WTE.

3.5 Availability of and Access to Debt Financing Options

The availability of and access to various debt financing mechanisms, particularly low-cost options, have a direct impact on the feasibility and viability of WTE projects and the overall prospects for the sector.

Concessional finance. In addition to grant-based VGF, sources of debt financing should be explored to ensure long-term growth of the WTE sector. For example, the India Infrastructure Finance Company Limited (IIFCL), which was incorporated as a wholly-owned Government of India company with the mandate to provide long-term finance to viable infrastructure projects, should be more actively engaged to support WTE sector development. Apart from direct lending to WTE projects, products such as refinancing and takeout-finance offered by IIFCL to commercial banks and other financial institutions can provide help to their infrastructure-lending portfolio and address asset–liability mismatches and exposure constraints, freeing up funds and increasing the availability of long-tenor debt finance for infrastructure projects like WTE (IIFCL 2016).

In parallel, concessional loans offered by multilateral development financial institutions, based on terms substantially more generous and favorable than prevailing commercial loan terms in local markets in the target countries, are an important source of low-cost debt financing. A typical example is the London Interbank Offered Rate-based loans offered by the Asian Development Bank (ADB 2016a). The interest rate of such loans is determined by the 6-month offered rate plus an effective contractual spread and, where applicable, a maturity premium fixed over the life of the loan. Moreover, the loan tenor usually includes a 5-year grace period. Overall, the interest rate is substantially lower than the prevailing loan interest rates offered by commercial banks.

Considering that a successful commercial-scale demonstration of WTE is essential to ensuring broader large-scale deployment, the Governments of Bangladesh, India, and the Philippines can explore the possibility of availing other financing products and modalities of multilateral development banks that can be tailor-made to align with programmatic efforts in facilitating the WTE demonstration and deployment.

Guarantees for commercial lending. Since WTE projects are often regarded as risky by risk-averse commercial creditors, developers face substantial risks and uncertainties in the availability and cost of debt financing offered by them, and therefore need credit enhancement mechanisms. Furthermore, under a PPP arrangement, a private developer and its creditors are exposed to the risk of the possible failure of the public sector in meeting its contractual obligations. Therefore, opportunities of availing of guarantee and risk mitigation products offered by multilateral development banks should be actively explored, with the purpose of enhancing project bankability and thus attractiveness to private sector developers, investors, and commercial lenders or creditors.

A typical guarantee mechanism for credit enhancement is a partial credit guarantee, which is extended to lenders or creditors of loans, bonds, financial leases, letters of credit, and so on to cover the risk of nonpayment by the borrower or issuer (the project developer) on the guaranteed portion of the principal and interest due (ADB 2016b; International Finance Corporation 2016).

The World Bank offers a risk mitigation product, a partial risk guarantee, that is designed to address the risks associated with potential default of a project developer on payment obligations caused by the failure of government to meet specific performance obligations under PPP arrangements, such as change of laws and regulations, failure to meet contractual payment obligations, failure to issue project licenses, failure to provide approvals and consents in a timely manner, etc. (World Bank 2016). Such a product will be helpful to reduce the risk exposure that private developers are subject to.

IV. ADB'S WASTE-TO-ENERGY EXPERIENCE

Since WTE projects require large upfront capital investment and high demand on operation technology, private sector can play a vital role in the sector's development. When the enabling environment for PPP is adequate, the private sector will show interest.

To help address the infrastructure and financing gap in Asia, the ADB has expanded its private sector operations, including providing financial support for private sector participation. For instance, based on enabling conditions, ADB funded several private companies to implement WTE in select cities of the PRC. ADB's first private sector WTE project supported China Everbright International, a leading player in WTE in the country, to build and operate six WTE facilities (capacity larger than 1,000 tons per day) with an aggregate capacity of 132 megawatts (MW) since 2009. ADB provided a $100 million direct loan and a $100 million syndicated commercial loan.[5]

In 2012, Dynagreen became the second WTE partner in the PRC, developing plants with a capacity of 500–1,000 tons per day on tertiary cities.[6] Together with the loans, ADB supported through technical assistance projects development of advanced grate incineration technology and meeting EU2000 standards for flue gas emission.

The risks and mitigations identified for the WTE projects focused on (i) waste supply risks including sufficient amount of waste supplied and confirmed responsibility for waste collection and delivery; (ii) waste quality risk including commingling of incombustibles or hazard waste, and sufficient heat value to run WTE; (iii) feed-in-tariff (FIT) including an offtake agreement as a must;[7] and (iv) waste tipping fee. Based on ADB's experience in the PRC, two-thirds of the revenue comes from FIT (as $0.106 per kilowatt-hour) and one-third comes from tipping fee ($8–$15 per ton on average). Therefore, it relies on the local government for municipal solid waste (MSW) supply and payment for tipping fees. Sound FIT schemes can attract private investors. WTE can potentially save the MSW management cost of local government. However, it cannot be an opportunity for revenue generation.

On the commercial side, concession agreement is crucial for proper risk allocation and overall structuring of the project. The coverage and contents of a concession agreement are for long term (25–30 years) with exclusive right, first refusal right, and termination regime. Government responsibilities include waste collection, segregation and delivery, land acquisition (if any), and the payment of tipping fee. Also, minimum waste supply guarantee is a must (waste quality guarantee preferred but not a must). Meanwhile, the private investor (concessionaire) commits to construction and operation of the WTE facility, in compliance with emission and other environmental standards, with arrangement of finance and responsibility of the concessionaire.

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[5] ADB. People's Republic of China. Municipal Waste-to-Energy Project. https://www.adb.org/projects/43901-014/main.

[6] ADB. People's Republic of China. Dynagreen Waste-to-Energy Project. https://www.adb.org/projects/46930-014/main.

[7] Offtake agreement is an agreement between a producer of a resource (in this case, power) and a buyer to purchase or sell portions of the producer's future production of the resource.

Normally, lenders' step-in rights are common features in the agreement.[8] In the PRC, there is a simple but commonly used concession agreement template. Additionally, power purchase agreement (PPA) with utility (or other offtake agreement) is also necessary before a WTE can be operational. The private sector investor and local government should carefully enter into a well-structured concession agreement with the right counterpart as it is key to attract commercial financing. Stable cash flow will come through a good concession agreement and PPA and/or FIT agreement. Only after such arrangement can the financier (such as ADB) be comfortable to enter long-term loans for project financing.

V. SCREENING PARAMETERS FOR INVESTING IN WASTE-TO-ENERGY

A table showing screening parameters was developed for the potential investor to evaluate a city's readiness for WTE (Table 3). It is analyzed from a sector financing side without any country specification.

Table 3: Screening Parameters for Investing in Waste-to-Energy Based on the People's Republic of China Experience

Parameter	Requirements
Waste supply risk	
• Sufficient amount of waste to be supplied continuously	At least 500 tons per day delivered to WTE facility
• Possibility of competing facilities in the future	Close management of open dumping
• Responsibility for waste collection and delivery	MSW supply chain is complete
Waste quality risk	
• Commingling of incombustibles or hazardous waste	Such part be removed by certain party
• Waste calorific value sufficient to run WTE plant without supplemental fuel?	Pilot study and test should be done
• Impact of economic development (waste amount and composition), promotion of recycling (proportion of plastic waste in particular)	High urbanization with high growth and high land value will facilitate this
Electricity tariff	
• Offtake agreement and feed-in-tariff or adder scheme	Related regulation and practice be in place
Waste tipping fee	
• Local governments always need to pay tipping fee	Local governments have reliable budget for tipping fee
• From ADB's experience in the PRC, two-thirds of revenue from FIT and one-third from tipping fee ($8–$15 per ton on average)	Financial viability be examined
• Reliance on local government for waste supply and payment of tipping fee	Local governments have good record on that
Coverage and contents of concession agreement	
• Long term (25–30 years), exclusive right, first refusal right, termination regime	Should be met
• Government responsibilities include waste collection, segregation and delivery, land acquisition (if any), and payment of tipping fee	Local governments have good record on that

continued on next page

[8] Step-in rights enable one party (the beneficiary) to "step in" to the shoes of another party in relation to the rights and obligations of a contract, typically, if there has been a serious breach of contract. Step-in rights can be used to enable a project to continue with one party being replaced by another.

Table 3 *continued*

Parameter	Requirements
• Minimum waste supply guarantees a must (waste quality guarantee preferred but not a must)	Should be met
• Private sector investor (concessionaire) commits to construction and operation of WTE facility, in compliance with emission and other environmental and social standards	Monitoring system be in place
• Arrangement of finance also responsibility of the concessionaire	Should be met
• Lenders' step-in rights a common feature	Should be met
• PRC – simple but commonly used concession agreement template	Commonly used template be on place
Power purchase agreement with utility (or other offtake agreement)	Should be met

ADB = Asian Development Bank, FIT = feed-in-tariff, MSW = municipal solid waste, PRC = People's Republic of China, WTE = waste-to-energy.

Source: Authors.

VI. CONCLUSION

Municipal solid waste (MSW) processing and disposal remains a challenge in Bangladesh, India, and the Philippines. The uptake of WTE as a proven MSW treatment solution has not been realized in Bangladesh and the Philippines. In India, the most recent WTE projects have not performed well and eventually ceased operations. Despite a well-established PPP regulatory framework and a mature PPP market for municipal infrastructure and public services, potential business opportunities in WTE in the three countries have not attracted private sector investors and financial institutions due to numerous barriers, and thus remain largely unexplored.

In contrast to these countries, WTE has evolved into a mainstream MSW treatment practice in the People's Republic of China (PRC), with PPP being the prevailing business model for developing and implementing WTE projects. The feasibility and benefits of PPP-based WTE have been demonstrated across regulatory, technical, financial, and environmental dimensions.

The Asian Development Bank (ADB) has experiences in supporting WTE in the PRC and can potentially expand financing to other worthy government and private sector initiatives in WTE given the right enabling environment as discussed in this working paper.

Countries and companies who want to introduce WTE should review their internal policy and regulatory environment, assess their MSW supply chain, and consider other key barriers to WTE investment. The screening table presented previously (Chapter 5) can help governments understand what private sector look for before choosing to invest in WTE, and it can likewise serve as a starting point for countries to consider what reforms are necessary to create the right enabling environment for WTE investments.

This paper has summarized and augmented ADB's experience on providing an enabling environment for successful private sector involvement in the implementation of WTE. The study has included three case studies and one reference country as benchmark. Based on research and analysis, the study concludes that the supply chain for WTE offers a viable solution to the growing problem of managing MSW provided that collection and treatment of solid waste is better developed. MSW management is well addressed in legislation, regulations, and guidelines but many of these are not practiced. Governments could choose to prioritize MSW along with its usual water supply and sanitation management. Incineration and WTE offer a viable solution to the rapidly accumulating solid waste problem and are likely to be simpler and more readily enacted than the alternative option of solid waste recycling.

WTE technology is mature and well understood in Europe and the United States and can be made available to developing countries through contractual mechanisms. Additionally, learning from the PRC experience can be utilized to help other countries in the region develop their WTE sector. The United Nations Human Settlements Programme or UN-Habitat has produced some practical material on WTE that could be simplified and made more readily available for local use in developing countries. The developing countries themselves have various documentation (including legislation, regulations, guidelines, and policies) that could be shared. The health and environmental impacts of poor municipal solid waste management are not yet well understood or appreciated, and more awareness and knowledge sharing is needed to remedy this.

All in all, the key issues revealed in the study were the uncertainty of the WTE facility supply chain, including the quality or heat value of the waste collected, and the form of WTE facility capital and operational costs recovery. If these are addressed, then there is a good chance a PPP for WTE project will succeed.

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Creating an Enabling Environment for Public–Private Partnerships in Waste-to-Energy Projects

As Asia and the Pacific continues to experience rapid urbanization with high population density, there is an increasing need to better manage municipal solid waste (MSW). One solution is to convert the waste to energy to reduce waste volume and minimize environment and social impacts.

This working paper conducted a review of the enabling environment for waste-to-energy (WTE) in the People's Republic of China (PRC), as well as in Bangladesh, India, and the Philippines. It examined the MSW management chain, institutional and regulatory policies involved, and potential public–private partnerships, of which the PRC is an active proponent of and can therefore provide lessons to other countries seeking to invest in WTE.

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