Large-scale Management of Unsegregated Municipal Solid Waste in Phnom Penh: A Cost Comparison of Three Options

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1. Introduction

In 2019, around one million tons of municipal solid waste (MSW) was sent to the Dangkor landfill in Phnom Penh, growing at an annual rate of 12%. While waste minimization and source separation should be encouraged and increased overtime, the vast majority of the MSW currently needs to be managed as a mixture. With the Dangkor landfill reaching its capacity, there is a need for large-scale options. This document examines three options from a construction and operational cost point of view: controlled landfill, incineration to energy, and refuse derived fuel (RDF). All options, if conducted properly, can mitigate the risk to the environment and human health created by MSW. While all three options have a high cost, incineration to energy and RDF create value and are therefore susceptible to attract private investment under the right conditions. These technologies also require much less land area compared to a landfill, which is an important factor given the increasing cost of land in Phnom Penh.

2. Cost Evaluation

2.1 The Cost of Building and Operating Landfills

Numerous studies have been conducted to assess the feasibility of new landfills in Cambodia, mainly by the Asian Development Bank (ADB). Recognizing that full sanitary landfills are too expensive to build and operate, these studies focus on “controlled landfills”, landfills with lesser environmental standards, and basic operation and maintenance (O&M), but still much better than open dumps. These landfills usually have a liner and basic leachate and gas collection system.

As well as the engineering of the landfill, purchasing equipment such as bulldozers, excavators, compactors, pumps, etc. is also required, resulting in high CAPEX. An additional parameter is that once these landfills are built, they are complex and expensive to maintain, often falling into disrepair rapidly as no money is allocated towards O&M. JICA’s feasibility study on the Dangkor landfill in 2005 recommended a gate fee of 4.4 USD/ton, to be increased over time. The current gate fee in 2020, when paid, is only USD 0.75/ton and the site is now an open dump.

Table 2.1 summarizes recent ADB landfill feasibility studies on towns around Cambodia, indicating very high CAPEX and OPEX compared to the volume of waste targeted, which would require the introduction of high landfill gate fees.

Table 2.1: Overview of landfill feasibility studies

Town	Waste projections (tons/day)			CAPEX (USD mn)	OPEX (USD)	Estimated OPEX/ton in 2018 (USD)	Estimated OPEX/ton in 2022 (USD)
	2018	2022	2040				
Pursat[1]	9	17	75	1.6	90,000	27.4	14.5
Kampong Chhnang[2]	6	12	49	1.5	65,400	29.9	14.9
Battambang[3]	63	93	230	6.5	184,000	8.0	5.4
Serei Saophaon[4]	31	42	110	3.05	189,000	16.7	12.3
Stung Saen[5]	6	17	52	2.8	102,000	46.6	16.4

However, it is difficult to compare these cities to Phnom Penh as they are much smaller in size. A more relevant example is a 2012 ADB study on the development of a new landfill in Tashkent City, Uzbekistan, which estimated CAPEX of USD 29 mn.[6] Tashkent had a population of 2.3 million people generating approximately 650,000 tons of waste per year, estimated to increase to 850,000 tons per year by 2030.

In neighboring countries, landfill gate fees average USD 20/ton in Vietnam, and USD 10-20/ton in Thailand depending on the size of the city. In addition, according to a World Bank report, the typical waste disposal cost to a controlled or sanitary landfill in low-income countries is USD 10-20/ton and USD 15-40/ton in lower-middle-income countries.[7]

2.2 The Cost of Incineration to Energy

Incineration consists of burning waste at high temperatures in a controlled environment and converting the heat into electricity via steam turbines. In South East Asia, the process requires pre-processing the waste to remove moisture and contaminants, effectively converting it into refuse derived fuel (RDF), to generate enough energy and control air emissions. Incinerators do not exist in Cambodia, but a relevant example in Vietnam, where GGGI supported a USD 60 mn incinerator project, recently reached financial closure. Such a project is possible in Vietnam because of the high landfill gate fees and the willingness of the government to provide appropriate feed-in tariffs (FIT).

For this project, the gate fee is USD 18/ton, slightly lower than the landfill gate fee, and the FIT is 10.05 USDc/Kwh. Because the project is financially sustainable, it attracted investment from the private sector and DFIs. Table 2.2 shows a summary of the cost and revenue.

[1] https://www.adb.org/sites/default/files/linked-documents/42285-013-sd-11.pdf
[2] https://www.adb.org/sites/default/files/linked-documents/42285-013-sd-10.pdf
[3] https://www.adb.org/sites/default/files/linked-documents/50102-002-sd-05.pdf
[4] https://www.adb.org/sites/default/files/linked-documents/50102-002-sd-05.pdf
[5] https://www.adb.org/sites/default/files/linked-documents/50102-002-sd-05.pdf
[6] https://www.adb.org/sites/default/files/project-document/75010/45366-003-uzb-tacr-cover-app1-9.pdf
[7] https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html

Table 2.2: Summary of the cost and revenue

Capacity (tons of waste/day)	**750-1,000**
Tipping Fee (USD/ton)	18
Feed in Tariff (USDc/Kwh)	10.05
Revenue from gate fee (mnUSD/year)	3.25
Electricity sale revenue (mnUSD/year)	8.25
Electricity output (MW)	10
CAPEX (mnUSD)	60
Internal rate of return (IRR)	12-15%

Incineration is also common in Thailand, again enabled by high landfill gate fees. A World Bank study calculated that for incineration the average CAPEX in China is USD 190–400/annual ton, and gate fees of USD 12–22/ton are required to break even, with relatively low-tech plants.[8]

2.3 The Cost of Refuse Derived Fuel

RDF is generated by mechanically sorting mixed MSW to remove moisture, contaminants, recyclables, and increase the calorific value. RDF can then be used as fuel in an incinerator or to replace coal in cement factories. GGGI conducted a pre-feasibility study on the development of an RDF to cement facility to be located at the Dangkor landfill in Phnom Penh. It recommends a gate fee of around 5 USD/ton to achieve financial sustainability high enough to attract private investment. At full capacity, this represents about USD 792,000/year to accept 158,400 tons of waste. Another 158,400 tons (50%) can be mined from the landfill, with no gate fee, to rehabilitate the site. The total CAPEX for the project, which includes an Anaerobic Digestor (AD) to process the organic fraction, is estimated at USD 18 mn. The table below shows a summary of the cost and revenue.

Table 2.3: Summary of the cost and revenue

Capacity (tons of waste/day)	**1,100**
Tipping Fee (USD/ton)	5
Revenue from gate fee (mnUSD/year)	0.79
Revenue from RDF sales (mnUSD/year)	3.4
CAPEX (mnUSD)	18
IRR	12-15%

03. Comparison

Due to the lack of relevant research around establishing a large-scale landfill in Cambodia, only incineration and RDF are compared to financial sustainability and subsidies requirements. Table 3.1 compares both projects, with the Vietnam incineration project benefiting from both a gate fee and FIT.

[8] https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html

Table 3.1 Comparison of RDF and incineration

Costs in Cambodian context (USD/mn)	Incineration	RDF
Capacity (tons of waste/day)	750-1,000	750-1,100
CAPEX (mnUSD)	60	18
Gate fee income	3.25	0.79
Electricity sale revenue	8.25	-
Typical EDC purchasing price	6.23	-
Annual subsidies required	**5.27**	**0.79**

The "typical EDC purchasing price" reflects the baseline EDC electricity buying price from neighboring countries, [9] and proposed government FIT for solar auctions in Cambodia, established at 7.6 USDc/Kwh.[10] It should be noted that EDC's FIT can vary widely depending on the technology proposed (coal, solar, etc.). The comparison shows that the CAPEX required to treat the same amount of waste by incineration is three times the CAPEX required for the RDF process. With the right level of subsidies, in the form of gate fees and FIT, both projects reach similar financial sustainability. However, incineration requires significantly higher government subsidies or users' fees: **5.27 USD mn/year** compared to only **0.79 USD mn/year** for the RDF project of the same scale.

04. Conclusion

Due to the very high volume of waste generated in Phnom Penh, a suite of technologies will be required to address the problem downstream, together with increasing efforts on waste minimization and source separation and recycling (composting, plastic, and glass recycling, etc.). Not all wastes can be recycled or used as fuel, and a new landfill will be required in the future to manage residual waste. However, minimizing the waste going to the landfill will reduce the CAPEX and prolong the life of the landfill.

A combination of RDF, incineration, and controlled landfill could be a suitable scenario for Phnom Penh, on the understanding that gate fees and high CAPEX are required regardless of the technology. Landfills require ongoing maintenance to avoid becoming open dumps, the large-scale landfill required in Phnom Penh would need to be funded by gate fees of at least 10 USD/ton. Incineration and RDF, on the other hand, have different sources of revenue and are more susceptible to attract private investment. RDF is a more suitable first step due to the lower CAPEX and gate fee, incineration can follow when the conditions are ripe, as the technology is currently too expensive for Cambodia.

Furthermore, the government is developing plans for a regional landfill far away from the city that will be serviced by three transfer stations, including one at the Dangkor landfill. Locating the RDF facility at Dangkor would minimize the amount of waste requiring further transport to the regional landfill, therefore reducing operational expenditure for the transport company such as fuel, vehicle maintenance, and salaries.

[9] https://www.phnompenhpost.com/business/cambodian-lao-coal-power-deal-environmental-worry

[10] http://www.edc.com.kh/images/INVITATION%20FOR%20BID%2060MW%20solar.pdf

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