Korea Green Growth Trust Fund
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SOLID AND INDUSTRIAL HAZARDOUS WASTE MANAGEMENT ASSESSMENT

OPTIONS AND ACTION AREA TO IMPLEMENT THE NATIONAL STRATEGY

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AFR	Alternative Fuels and Raw Materials
approx.	approximately
BAT	Best Available Techniques
BREF	Best Available Techniques Reference Document
CAPEX	Capital Expenditure
C&D	Construction & Demolition Waste
CNY	Chinese Yuan
CPC	City People's Committee
DOC	Department of Construction
DOF	Department of Finance
DSW	domestic solid waste or garbage
DSWM	Domestic Solid Waste Management
DONRE	Department of Natural Resources and Environment
EIA	Environmental Impact Assessment
EPR	include Extended Producer Responsibility
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ha	hectare
HCMC	Ho Chi Minh City
HH	household
HW	hazardous waste
ISWM	Integrated Solid Waste Management
IW	Industrial Waste
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JSC	Joint Stock Company
KJ	kilojoules
kg	kilogram
kg/cap/day	kilogram per capital per day
KfW	Kreditanstalt Für Wiederaufbau (German Development Bank)
kg/pers./day	kilogram per person per day
KWTF	Kitchen Waste Treatment Facility (KWTF) pers./da
KGGTF	Korean Green Growth Trust Fund

GSO	General Statistics Office
LF	landfill
MBT	Mechanical Biological Treatment
mln	million
MARD	Ministry of Agriculture and Rural Development
MJ	Megajoules
MOC	Ministry of Construction
MOF	Ministry of Finance
MOH	Ministry of Health
MOIT	Ministry of Information and Technology
MONRE	Ministry of Natural Resources and Environment
MOST	Ministry of Science and Technology
MPI	Ministry of Planning and Investment
MRF	Material Recovery Facility
MSW	Municipal Solid Wastes
NDC	Nationally Determined Contributions
No	Number
ODA	Official Development Assistance
O&M	Operation and Maintenance
OPEX	Operational Expenditure
PCB	Polychlorinated biphenyl
RDF	Refuse Derived Fuel
PPC	Provincial People's Committee
PR	public relation
SOE	State Owned Enterprise
SPV	Special Purpose Vehicle
SW	solid waste
SWM	solid waste management
ToR	Terms of Reference
t	ton
t/y	ton per year
t/d	ton per day
UMCO	Urban Management Company (similar to URENCO)
URENCO	City's Urban Environment Company
US$	United States Dollar
VAT	Value Added Tax
VND	Vietnamese DONG
WB	World Bank
WEEE	Waste Electrical and Electronic Equipment
WtE	Waste to Energy

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EXECUTIVE SUMMARY

Urbanization, together with strong economic and population growth are causing rapidly increasing domestic waste volumes, with waste generation in Vietnam doubling in less than 15 years. The total amount of waste generated is estimated at over 27 million tons. With a forecasted growth rate in domestic solid waste generation of 8.4% per year for urban areas and a total growth rate of about 5% annually, the amount of waste is expected to grow to 54 million tons nationally in 2030. For the three focus solid waste areas under this study: (i) the total amount of waste is estimated in Hanoi to grow by 4.75% annually to 5.6 million tons per year in 2030; (ii) the total amount of waste is expected to grow annually in Phu Tho by 5.10% to almost 1 million tons in 2030; and (iii) in Hai Phong, which has a larger rural population, the total amount of waste is estimated to growth by 3.2% annually, reaching 1.15 million tons in 2030.

Vietnam has committed itself to move towards collecting, transporting and treating 100% of non-household waste by 2025 and 85% of waste discharged by households by 2025 in urban areas through its recently approved revised National Strategy on Solid Waste Management. Priority is envisaged to be given to large-scale treatment facilities using modern technologies with a substantial focus on recycling and upgrading landfills to prevent environmental and health impacts.

Municipalities, regional and central governments, however, are currently struggling with the collection, transport, treatment and disposal of the growing waste streams. Vietnam has grown so rapidly and waste generation has increased so much, that the collection, transport, disposal and treatment systems and the financing for these systems, has been unable to keep up with the increased volumes of waste being produced:

› **Current waste operations are labour intensive and inefficient; fees do not even cover the operational costs.** Waste collection and transport is characterized by fine-grained and labour-intensive collection. Due to the lack of transfer stations, small waste collection trucks must travel substantial distances to the landfill sites. Both the labour-intensive collection and lack of transfer stations leads to relatively high collection and transport costs. Analysis carried out as a part of this study suggest inefficiencies and high numbers of employees. **The current real costs per ton of waste are estimated to be** US$24 for collection, US$11 for transport and US$4 for landfilling, with **a total of US$39** for Hanoi; **while the average fee** per household **is VND 26,500/household/month or VND 218,630/ton[1] (US$ 9.7/ton)** comprised of VND 172,600/ton (US$ 7.6/ton) for collection and VND 46,030/ton (US$ 2/ton) for transport. The difference between the costs of waste

1 Based on calculated 1.46 tons of waste generated per household per year

management and the fees received are covered by the respective Provincial/City Peoples Committees.

› **Waste recycling is dominated by the informal sector where processing of recyclables is carried out in craft villages without proper monitoring of operational practices, leading to significant pollution and health hazards to workers and environment.** Vietnam is home to 2,800 craft villages that include not just those that make handicrafts for tourists, but many villages where industrial activities take place as well as those that specialize in recycling all sorts of discarded plastic, including from waste streams. The informal sector typically gathers the most valuable recyclables directly from households and at street level before the waste enters the formal collection channel. The informal sector separates, bales and sells the products to the processing industry, recycling about 10% of the domestic solid waste. Processing of recyclables is mostly carried out in these craft villages without proper regulation, monitoring and enforcement of operating practices. These activities lead to substantial pollution of air, water and land and cause serious health hazards for the workers. At the same time, craft villages provide considerable employment.

› **There is low public awareness and insufficient access to a formal waste collection and recycling system, which leads to substantial illegal littering of wastes by households in the canals, lakes and paddy fields and on the beaches and in oceans.** Some volunteer groups, such as "Keep Hanoi Clean[2]" are devoted to citizen engagement initiatives to clean cities and raise the public profile of the solid waste issues, but this is not sufficient to avoid the accumulation of waste and plastics in the environment.

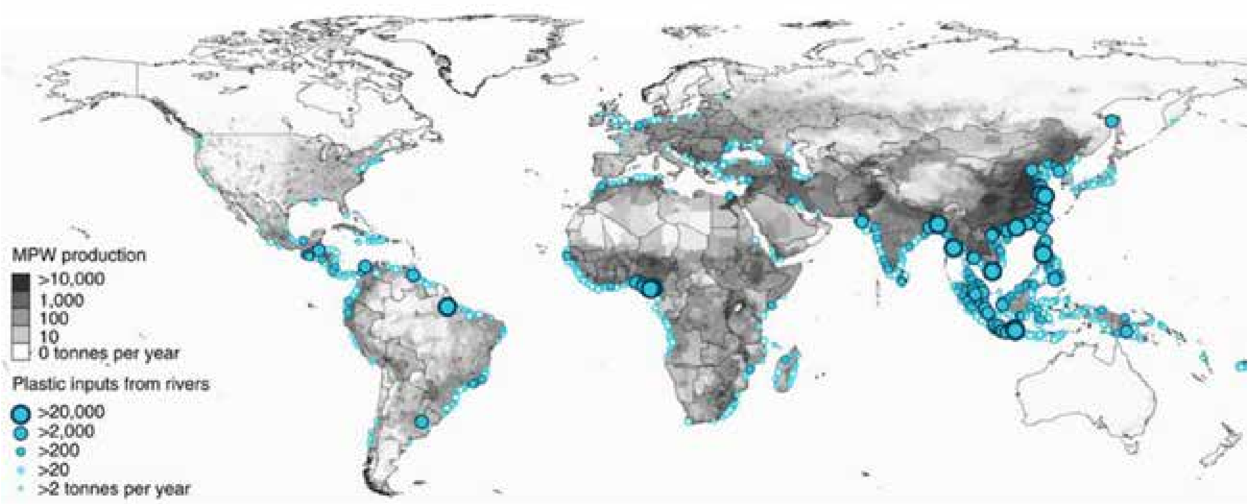
› **Even for the waste that is collected by municipalities, most it is still disposed of in insufficiently designed and poorly controlled landfills causing significant environmental issues.** There are 660 landfills in Vietnam receiving some 20,200 tons of waste daily. Out of these 660 waste disposal sites across the country, only 30% can be classified as engineered landfills with daily coverage of waste. The cities of Hanoi and Ho Chi Minh City (HCMC) have mega landfills covering areas of 85 ha and 130 ha respectively. Only 9% of the landfills have weighing scales and only 36% have a bottom lining. Most of landfills

Photo: Waterway at Minh Khai village in "Development and Society, a look at Vietnam's plastic craft villages"

2 https://www.facebook.czom/groups/keephanoiclean/

have no compactor, landfill gas collection, leachate treatment or environmental monitoring system and are poorly managed, mostly due to lack of funding. This is causing multiple environmental and health problems and risks particularly in areas with high waste generation levels and population density, including: (i) groundwater contamination having a direct impact on the water wells of the communities who are living around the landfills; (ii) contamination of surface waters through the discharge of toxic liquid wastes without adequate leachate treatment or as a result of poor operational practices; (iii) polluting air emissions from landfill gas releases or from open waste burning; (iv) health risks, especially for the many scavengers; (v) animals (flies, cockroaches, rats) spreading illnesses; and (v) spreading of waste, particularly plastics, to surrounding environment and further into the river and ocean system.

The uncovered waste and the large number of small, poorly located landfills/dumpsites together with the waste littered by households and incorrectly recycled in craft villages **are the causes of plastics being blown by the wind over the rice fields, into canals and rivers and ending up on Vietnam's beaches and in the ocean.** Land-based sources of poorly managed plastics are estimated to be responsible for 80% of the ocean plastics[3]. The presence of plastics in coastal areas, beaches and other key natural tourism destinations, such as Halong Bay, causes substantial economic damage to Vietnam's tourism industry[4]. These shortcomings in waste management are negatively affecting economic development and sustainable growth in Vietnam. The Asia-Pacific Economic Cooperation estimates the costs of marine plastics and debris to the tourism, fishing, and shipping industries to be US$1.3 billion for the Asia-Pacific region[5].



The top 20 polluting rivers, mostly located in Asia, account for 67% of the global total, with 74% of the plastic discharge occurring between May and October. (Lebreton, L. C. M. et al. River plastic emissions to the world's oceans. Nat. Commun. 8, 15611 doi: 10.1038/ncomms15611 (2017)).

Disclaimer: The map shown is for illustration purpose. The boundaries, color, denominations, and other information shown on any map in this work do not imply any judgment on the part of the World Bank Group concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

3 Stemming the tide: Land-based strategies for a plastic-free ocean, Ocean Conservancy with McKinsey Center for Business and Environment.

4 http://www.abc.net.au/news/2015-10-02/tourism-coal-shipping-vietnam-ha-long-bay-rubbish/6821568

5 McIlgorm, A., Campbell H. F. and Rule M. J. (2008). Understanding the economic benefits and costs of controlling marine debris in the APEC region (MRC 02/2007). A report to the Asia-Pacific Economic Cooperation Marine Resource Conservation Working Group by the National Marine Science Centre (University of New England and Southern Cross University), Coffs Harbour, NSW, Australia, December.

Several cities and provinces have introduced more advanced waste technologies with mixed success and are eager to introduce composting and incinerator technologies to reduce landfilling needs. Nationally, about 22% of the collected waste currently goes to various treatment facilities, instead of landfilling[6]. For the three areas under this study: In **Hanoi**, two compost plants were operated until a few years ago, but the operation was stopped as the compost was unsalable due to poor quality. Hanoi is interested in developing an incineration facility for solid waste. In **Phu Tho**, a waste treatment plant was established in 1998, including a composting plant and small incinerator. The small incinerator broke down in 2005 and the composting facility is expected to close soon as there is little market interest in the compost due to the high presence of contaminants, such as plastics, metals, glass etc. In addition, several small incinerators were established to treat domestic waste in some districts. However, due to poor flue gas cleaning equipment, they have not yet met the environmental protection requirements. Phu Tho province plans to establish a larger incinerator for domestic solid waste with electricity generation, for which the technical appraisal is ongoing. At this stage, it is not clear if the waste that will feed the incinerator can meet the calorific requirements for incineration (typically more than 9,000 KJ/kg). Probably a large part of the organic fraction would need to be removed from the waste stream to meet this requirement. Furthermore, since the air emission control equipment for the incinerator has not yet been selected, the equipment's capacity to meet Vietnamese regulations is currently unclear. In **Hai Phong**, there is an existing composting plant which has been producing compost based on mixed domestic solid waste. Similar to Hanoi, the compost produced by the plant is unsalable due to poor quality. A new composting plant which uses organic waste input from markets and urban tree trimmings is being piloted in Hai Phong. The plant is producing a higher quality compost which is currently undergoing testing. Hai Phong is constructing one new landfill and is interested in modernizing the existing landfills as the current ones in operation are full and without adequate environmental protection.

International experience suggests that in order to progress towards the approved waste management targets, a realistic masterplan/ roadmap for future waste management should be developed which should considers financial sustainability of the infrastructure, affordability, institutional and legal reforms and capacity building and public awareness/ outreach. With such a broad spectrum of reform, infrastructure and capacity building needs, priorities and action areas must be defined and cost effectiveness considerations and social acceptance criteria should play a role in the decision-making process.

To inform the process of implementation of the National Strategy for Solid Waste Management, four key options/scenarios for improvements in domestic solid waste management in Hanoi, Phu Tho and Hai Phong were analysed and then extrapolated to the national level. The options/scenarios were deliberately selected to represent distinctly different solid waste sector development trajectories to allow for easy comparison of the investment needs and annual operational costs, expected results in waste reduction, accompanying requirements for waste fees. The scenarios also take into account international affordability benchmarks and the remaining financing gaps for cost recovery for public or private financing of the infrastructure. The options/scenarios are presented below:

6 Informal recycling 10%, composting 4%, incineration 14%.

1. Option/Scenario 1 – Basic modernized solid waste management system

Environmentally compliant and optimized: near 100% collection coverage in urban areas; optimize transfer and transport and utilize and construct sanitary and fully compliant landfills. This scenario includes full collection coverage with modernized collection and transport vehicles, transfer stations and environmentally compliant landfills. These components are also included in the other options/scenario's as they are universally required, although costs vary depending on the amount of waste requiring landfilling.

2. Option/Scenario 2 – Waste reduction, reuse and recycling at source (household level)

Optimization of waste reduction, reuse and recycling at the source (the households), in addition to the waste recycling that is currently already undertaken by the informal sector. All remaining streams as under option/scenario 1.

3. Option/Scenario 3 – Lower cost advanced waste treatment

Low grade composting or conversion of organic waste to animal protein, production of Refuse Derived Fuel (RDF), mechanical biological treatment (all residues to landfill), modernization of collection and transport and environmentally compliant landfills.

4. Option/Scenario 4 – Most advanced waste treatment technologies

Such as Waste-to-Energy, incineration facilities. Residuals and waste not suitable for incineration to landfill, modernization of collection and transport and environmentally compliant landfills.

The four options/scenarios are analyzed in detail against the following criteria: (i) the amount of waste forecasted to be generated **until 2030**; (ii) the resulting **waste needing landfilling** depending on the amount of more advanced recycling or treatment per option/scenario; (iii) the cost per ton; (iv) the **required increase in user fees per year** according to the international benchmark of affordability which amounts to 1%-1.5% average household income; (v) the **share of the costs that are covered by the increased user fees** if they are increased to 1%-1.5% of average household income; and (vi) the **remaining financing gap** in US$ million per year. The results are presented in the table below for the three cities under study.

Option 1: Basic Solid Waste Management System	Hanoi	Hai Phong	Phu Tho
Amount of waste in 2030 (ton/year)	4,703,520	950,762	772,368
Accumulated waste to landfill to 2030 (ton)	43,578,676	10,217,052	6,833,601
Average required user fee (US$/person/year)	13	14	13
Average required fee per ton in US$	32	35	37
Average required user fee (VND/person/year)	301,829	317,552	289,899
Average required fee per ton in VND	731,800	786,637	731,800
Average cost recovery based on increased fees according to affordability benchmarks of 1%-1.5% of household income	48%-72%	46%-69%	50-75%
Annual financing gap in US$ mln per year	36.5-68	43-75	31-63

Option 2: Waste reduction, reuse and recycling at household level	Hanoi	Hai Phong	Phu Tho
Amount of waste in 2030 (tons/year)	2,719,597	653,459	523,713
Accumulated waste to landfill to 2030 (ton)	31,951,064	8,330,467	5,407,746
Average required user fee (US$/person/year)	12	13	12
Average required fee per ton in US$	31	33	34
Average required user fee (VND/person/year)	265,974	303,117	273,380
Average required fee per ton in VND	694,700	750,879	781,975
Average cost recovery based on increased fees according to affordability benchmarks of 1%-1.5% of household income	55%-82%	48%-72%	53%-80%
Annual financing gap in US$ mln per year	21-52	37-69	24-56

Option 3: Lower costs advanced treatment	Hanoi	Hai Phong	Phu Tho
Amount of waste in 2030 (tons/year)	1,556,081	314,544	255,740
Accumulated waste to landfill to 2030 (ton)	17,379,614	4,129,430	2,712,607
Average required user fee (US$/person/year)	27	31	27
Average required fee per ton in US$	66	76	77
Average required user fee (VND/person/year)	614,301	700,705	608,340
Average required fee per ton in VND	1,488,610	1,735,781	1,740,093
Average cost recovery based on increased fees according to affordability benchmarks of 1%-1.5% of household income	24-35%	21%-31%	24-36%
Annual financing gap in US$ mln per year	172-204	208-241	170-201

Option 4: Advanced waste treatment	Hanoi	Hai Phong	Phu Tho
Amount of waste in 2030 (tons/year)	319,913	318,837	200,800
Accumulated waste to landfill to 2030 (ton)	11,056,129	5,466,610	2,631,071
Average required user fee (US$/person/year)	39	35	34
Average required fee per ton in US$	94	87	98
Average required user fee (VND/person/year)	883,475	793,824	778,941
Average required fee per ton in VND	2,140,886	1,966,455	2,228,078
Average cost recovery based on increased fees according to affordability benchmarks of 1%-1.5% of household income	16%-25%	18%-23%	19%-28%
Annual financing gap in US$ mln per year	289-321	250-282	244-275

Source: WB staff and consultants, using DONRE and GSO[7], MOC data

7 GSO: General Statistics Offices.

A substantial increase in waste infrastructure including modernization of collection, transport, disposal and treatment facilities is required to meet the large anticipated increase in the quantity of waste produced, regardless of which improved solid waste management system is implemented. The analysis for the different scenario's is summarized as follows:

The first option/scenario is the first required step in the modernization process but implies a continued need for large landfill capacities to be established in the future. The second option/scenario is the most cost-effective but would take a longer time to implement as recycling activities are currently rudimentary and dominated by the informal sector, prior to the waste entering the formal collection channel. Increasing recycling and reuse activities by households requires full containerization of the waste collection (and separation) system with large public education and awareness campaigns and would require incorporating the informal sector slowly into the official waste management and recycling sector.

The second option/scenario is ideally implemented in conjunction with investments in more advanced waste treatment systems that can receive the mixed household waste and pre-treat and treat this further while the infrastructure and education for increased household recycling is expanded in parallel. Particularly, source separation of organic waste fractions should be introduced in steps, initially through pilot projects focusing on major organic waste sources and then at the ward/community level and eventually at household level, where feasible.

Due to the high content of organics in the waste (50-80%), the relatively low content of dry recyclables (10-25%)[8] and a high content of inert waste (probably coming from street sweepings) of 15-38%, the energy content is low i.e. 900-1,200 kcal/kg or 3.6-4.8 MJ/kg. Waste incineration needs at least 7 MJ/kg. which implies that waste pre-treatment such as the mechanical separation, that is the basis for the third option/scenario, is required before incarnation or co-incineration can take place. Therefore, separation and pre-treatment of waste is needed to allow production of Refuse Derived Fuel (RDF) that could be then be used as a fuel either in dedicated Waste-to-Energy plants or for co-incineration at existing cement plants. While gradually improving household source separation, mechanical biological treatment systems can be included to separate the fractions produced as mixed waste from households.

Separate incineration facilities as foreseen under the fourth option/scenario, are an option used by several countries to reduce the amount of solid waste requiring disposal to landfill, and to recover energy in the form of heat and/or electricity. Countries where separate incineration facilities are widely used are typical countries where available land for landfilling is limited and landfill gate fees are high. Even though a certain cost reduction can be obtained by selling electricity and in some cases also the excess heat generated by incineration plants, incineration remains a much more expensive option than other treatment technologies. The higher cost is due to the separation and pre-treatment of waste with a high organic fraction, in order to produce Refuse Derived Fuel (RDF) that is suitable for incineration. Once RDF is produced it is expected to be more cost-efficient to co-incinerate the RDF in cement plants that already exist throughout Vietnam and would likely be willing to co-incinerate the RDF for a lower fee that would be applicable

8 The low content of recyclables in the formal waste stream is also since the informal sector/private entities have collected the most valuable materials before the waste enters the waste container.

at a dedicated separated incineration/Waste-to-Energy Plant[9].

Therefore, the total investment costs for all of Vietnam for introducing modern solid waste systems, including mechanical-biological treatment facilities as per the third option/scenario are estimated to reach US$13 billion by 2030. This estimate excludes operational costs which are estimated to be growing to US$2.2 billion annually by 2030. These modernized solid waste systems include new waste collection equipment, transportation trucks and transfer stations placed at mechanical biological treatment facilities. At these treatment facilities, waste is mechanically separated and biological treatment of organic waste fraction takes place with production of Refused Derived Fuel (plastics, paper, carton etc.), that can be incinerated[10] and the residuals disposed to sanitary landfills with liners, gas collection and leachate collection and treatment and in line with international standards.

Hazardous waste. The current situation regarding the hazardous waste management in Vietnam is well regulated, and all of the industrial enterprises that were visited are fulfilling the requirements regarding hazardous waste management, including storage of hazardous waste, entering into agreements with service providers, and reporting to the respective Departments of Natural Resources and Environment regarding the enterprises' annual hazardous waste generation. The overall picture of the Hazardous Waste treatment facilities in Vietnam, is that these treatment facilities are relatively small in design/permit capacity, e.g. the majority of the incineration facilities have a capacity of 1,000 kg/hour, equivalent to 7,500 tons/year. In Europe a HW incineration kiln is typically in the size range of 40,000 – 60,000 tons/year and serve a larger number of enterprises in several regions. There is scope for improvement of industry compliance with the regulations through increased monitoring, inspection and enforcement.

Regarding the wastes, and in particular the non-hazardous waste types, generated by the mining, the steel production and the energy generation industries in Vietnam, it is recommended to investigate the options for new waste treatment processes, e.g. fly ashes from the power plants and steel producing enterprises, paste from lead and zinc extraction. The main report contains an overview of Best Available Techniques for these waste streams.

In provinces where the industrial enterprises are generating smaller quantities of hazardous waste (e.g. Binh Thuan and Bac Kan Provinces), analysis should be carried out to determine whether the current joint stock companies could establish intermediate storage facilities for the hazardous waste. The intermediate storage facilities could operate as a collection station for the hazardous waste generated by the small generators in the province prior to the transport of the waste to the hazardous waste treatment facilities operating in the neighbouring provinces. The following key challenges for hazardous waste are identified:

› Lack of disposal options for several industrial hazardous and non-hazardous waste types, e.g. residues from mining activities and steel production, and dry ashes from

9 This potential for cement kilns to use RDF as co-incineration is currently studies in more detail to analyze the investment required at industry level, the key waste streams that have the potential to be priority waste streams for alternative fuels, market potential as well as key bottlenecks and the possible Greenhouse Gas Emission Reduction and potential for cooperation with the private sector. The key priority waste streams for co-incineration are: (i) RDF from municipal waste, (ii) dried sewage sludge; (iii) tire derived waste; (iv) persistent organic pesticides; and (v) PCBs. This analysis is being undertaken by the World Bank under the NDC partnership facility and the draft report will be available for presentation and discussion in September 2018 and its analysis, results and recommendations will be incorporated in the overall study and policy note.

10 Potential fees of cement plant for co-incineration not included in cost estimate; however, if the RDF meets the specifications of the plants then experience from other countries suggest that cement plants are typically willing to accept the waste without charge.

energy production. The industrial facilities are forced to either store the waste at their own premises or dispose of the waste in an inappropriate manner.

- Lack of environmentally acceptable treatment /disposal options. The incineration facilities are not in compliance with international regulations
- Lack of a proper record (database) of current hazardous waste treatment facilities.
- Lack of planning for the regional treatment capacity needs, which has caused uncoordinated establishment of numerous small incineration plants (1,000-2,000 kg/hour)
- Lack of continuous flue gas emission measurements at incineration plants
- Insufficient flue gas treatment at incineration plants. Black smoke has been observed at some hazardous waste treatment facilities.
- Proper classification of residues from metal exploration

The Way Forward for implementing the National Strategy on Solid Waste

Vietnam is on a trajectory where the solid waste sector needs modernization in line with the urbanization and economic growth of the country. With the lack of environmentally compliant landfills, the large informal sector involved in collecting recyclables, the littering of waste in many places and the lack of proper disposal and limited advanced treatment, the solid waste system is basically operating as a small rural society unsuited to the needs of an urbanized country that is growing economically.

Vietnam will therefore need to envision a phased-approach of gradual improvements to its solid waste management to move towards a modern, integrated and sustainable solid waste management system at affordable costs and this will require changes across all levels and dimensions in addition to new technology and infrastructure to reach the targets as foreseen in its National Strategy. The recommendations are categorized according to these dimensions: (i) solid waste management infrastructure/ facilities; (ii) sustainable financing and waste fees; (iii) legislative and regulatory framework, policies to reduce waste and institutional arrangements, including private sector participation; (iv) education, public awareness and participation and capacity building.

Solid Waste Management Infrastructure/facilities

Regional sanitary landfills are a basic requirement in any waste management system even when these include more advanced treatment facilities. Despite the objective of fast introduction of advanced recycling schemes and treatment facilities such as waste-to-energy plants, and the potential to reduce certain (plastic) waste streams, basic improvements to the collection and transport system and disposal infrastructure are needed to modernize and optimize collection and transport and minimize the environmental impacts of disposal.

Landfills will be required for a least a certain fraction of the waste, even advanced waste treatment systems such as incineration facilities are successfully integrated; and urgent rehabilitation of the current landfills are required to minimize the environmental and health impacts. The current landfills without landfill gas collection, adequate leachate treatment or bottom liner and absence of sufficient compaction and daily covering of waste, needs urgent improvement to reduce the environmental impacts of landfills.

More attention is also required for the modernization of collection and transport of waste, moving towards containerization of collection -particularly in the high-rise areas- and optimization of collection and transport, including transfer stations. Optimizing collection, transport and landfill disposal is also important in order to focus on the affordability of the system which aims for cost-recovery levels not requiring fee levels of more than 1.5 percent of household income and reducing the amount of state subsidies required.

While several local governments are considering the introduction of waste-to-energy facilities, consideration should also be given to separate the waste by removing the organic fraction and pre-treating the waste so that Refuse Derived Fuel is produced that could be co-incinerated in the wide spread cement industry in Vietnam. The high organic fraction in the waste is estimated to range between 50%-70% with a corresponding high moisture content that will require the waste to be separated and pre-treated to remove the organic fraction and moisture and to reduce proportion of inert materials such as dirt and rubble and other non-combustible materials, in order to meet the requirements for incineration[11]. Recyclables and hence the materials that have high calorific value suitable for incineration are to a large extent already removed by the informal sector, before the waste is formally collected.

Therefore, a focus on separate collection of the large organic streams appears to be a lower cost strategy to achieve waste reduction and reduce the need for landfilling. Separating the waste mechanically through properly protected manual separation with subsequent pre-treatment to produce Refuse Derived Fuel for co-(incineration), would enable use of the organic fraction to produce high quality compost or biogas. This change would need to be combined with formalizing the current informal waste collection to reduce the plastic leakage into the environment, improve the workers' health and safety and ensure that part of the non-recyclable plastic fraction enters the formal waste system to produce Refuse Derived Fuel.

The presence of the cement industry in Vietnam means that dedicated waste incinerators may not be necessary if a competitive cost-effective market for cement co-incineration can be developed. The major advantage of cement kilns is that they already exist in Vietnam, are quite tolerant to waste composition, can offer environmentally safe and economical solutions and several plants have expressed interest in co-incineration. However, there is a need to ensure that cement plants are equipped with proper flue gas cleaning and waste feeding systems before co-incineration of Refuse Derive Fuel (RDF) is done. Some cement plants in Vietnam already have sufficient capacity to use RDF.

Sustainable financing and waste fees

Sustainable financing of the infrastructure and particularly modern and more advanced waste treatment systems is needed. These advanced systems are more expensive and will require an increase in waste fees to construct and maintain the waste system to an acceptable service standard. In addition to the substantial investments that are planned and needed for advanced and expensive waste treatment facilities and to modernize collection, transport and landfilling, the operational costs required to manage and maintain them will subsequently also increase substantially. International experience demonstrates that up to two thirds of the life-time costs in solid waste management are generated by operational expenses and municipalities can spend more than half of their budget funds on solid waste management services, if costs are poorly managed and the waste fees that are collected are too low. When considering more advanced and expensive waste treatment infrastructure, such as incineration facilities (Waste-to-Energy Plants), the Government need to decide on the cost-recovery targets it aims for; by when they should be achieved and the amount of

11 Calorific requirements preferably more than 9,000 KJ/kg; low moisture content of less than 35%.

subsidies that will be needed until such cost-recovery is achieved.

Across collection and disposal operations, waste collection typically accounts for 60-70% of total costs. However, disposal/treatment costs are expected to increase substantially with more advanced sorting and materials recovery choices and Waste-to-Energy incineration. Disposal costs vary widely and when waste disposal is informal then there is no accounting for it in the formal costs. A benchmark of Vietnam as a Lower Middle-Income country compared to typical waste management fees for collection and transport/transfer, disposal and more advanced treatment options is provided in the table below.

Vietnam's costs of landfilling of US$4 per ton are very low and represent an underspend when compared to landfill costs required in properly engineered and controlled landfills without impacts to the surrounding environment. The costs for landfilling are considerably below what properly engineered landfills with landfill gas recovery, leachate treatment and daily waste covering would cost to ensure environmentally compliant operations and be more representative of the costs of open dumping. Even with these low current landfill costs, there is no gate fee charged to cover the costs from waste charges.

Without gate fees and taxes for landfilling, it will be difficult for other -more expensive- waste treatment systems to become competitive, as landfilling will remain the cheapest option. Introduction of gate fees and landfill taxes is a requirement for waste generators to be willing to pay a higher cost/fee for waste treatment as otherwise there are no incentives to continue disposal at the landfills for free.

In order to cover the investment costs for modern solid waste systems, including mechanical-biological treatment facilities as per the third option/scenario and the accompanying operational costs, the average cost per person per year is expected to be in the order of US$20 or VND 470,000. These costs are much higher than currently covered by waste fees (which are 26,500 VND per household per month or 79,500 VND per person per year) and the waste fees need to be substantially increased. The affordable annual fee per person, based on internationally determined benchmarks of 1% - 1.5% of household income would be VND 145,350 – 218,025, which would still cover only 31%-47% of the costs and would therefore require substantial further financing/subsidy from cities and provinces. For many cities, the long-term environmental benefits, including the availability of raw materials, and the preservation of land value, outweigh the higher costs for solid waste management

	Low-income countries (US$/ton)	Lower middle-income countries (US$/ton)	Upper middle-income countries (US$/ton)	High-income countries (US$/ton)
Collection & Transfer	20-50	30-75	50-100	90-200
Controlled Landfill to Sanitary landfill	10-20	15-40	25-65	40-100
Open dumping	2-8	3-10	-	-
Recycling	0-25	5-30	5-50	30-80
Composting	5-30	10-40	20-75	35-90

Source: World Bank, What-a-waste 2.0, 2018[12].

12 Kaza, Silpa, Lisa Yao, and Perinaz Bhada-Tata. 2018. What a Waste 2.0: A Global Snapshot of Waste Management to 2050. Urban Development Series. Washington, DC; World Bank. doi:10.1596/978-1-4648-1329-0. License: Creative Commons Attribution CC BY 3.0 IGO.

and therefore the increase of fees to support modernized solid waste management is a good way forward.

In addition, the ability and willingness to pay for improved services must be considered when developing this waste management strategy to keep costs at an acceptable and affordable level. In principle, user fees should initially cover the operating costs of the waste management system. Transfers and subsidies may be required during a transition period when investing in more modern and advanced systems in order to manage a gradual increase in fees. Low income groups which cannot afford full fees will need support in the form of targeted subsidies. Such a strategy also needs to develop a time-frame for fee increases in parallel with solid waste management service improvements, including a financing strategy for the capital expenditure, through loans, grants and partnerships with the private sector.

Legislative and regulatory framework, policies and institutional arrangements including private sector participation

The institutional and regulatory framework for waste collection, treatment and disposal and planning of waste infrastructure is unsuitable for the much more expensive waste treatment and private sector participation. The current collection system is rather complex with numerous state-owned and joint-stock companies in charge of collection, causing difficulty in organization and integration of transport activities and transport routing[13]. Improvement of the legal and regulatory framework is needed to promote accountability. Solid Waste Management targets, norms and minimum operation and environmental standards need to be clearly defined in the legal framework against which stakeholders can be held accountable.

Non-compliance with established norms and standards needs to be enforced by a transparent fine system which requires independent monitoring and enforcement bodies with sufficient capacity and funding. The monitoring, inspection and enforcement functions of the Departments of Natural Resources and Environment in the regions, needs to be strengthened, included their capacities.

Private sector participation is only successful, when: (i) Detailed legislation on solid waste management is prepared and introduced, including proper definitions of the duties and responsibilities of all the stakeholders involved. This includes detailed rules and decrees on how waste must be handled at source, during collection, transportation, treatment and/or final disposal; (ii) The relevant legislation must be enforced, meaning that competent authorities must control waste management at the various stages from the point of generation until final disposal and fine those who do not respect the laws; (iii) There must be a proper contractual basis for involving the private sector at the various stages of solid waste management. For example, collection and transportation services must be tendered according to minimum 5-year contracts, which will enable private operators to write off investments in collection and transportation equipment. For large private investments in treatment facilities, longer concession agreements of e.g. 15-20 years duration should be established. Fixed prices and contractual conditions must be ensured during the entire contract/concession period; and (iv) The responsible authority – e.g. the Province/City must possess the necessary institutional (organizational capacity and skills to control the establishment and proper management of any agreement on private sector participation. This includes availability of staff with relevant education and experience.

13 e.g. Hanoi: 18 units including 8 state-owned companies and 9 joint stock companies and one cooperative; HCMC has 23 state-owned companies, 5 cooperatives and 30 private companies for waste collection.

Education, public awareness and participation and capacity building

Substantial increase in citizen and youth education on waste reduction, halting waste littering and possibly future source-separation and waste recycling is required as a basis to support more cost-effective waste management infrastructure systems and reduce the littering in the environment and subsequently rivers and oceans. Countries and cities are increasingly focusing on solid waste management and environmental education to reduce waste generation and improve sorting and collection systems. There is also an effort to improve recycling systems to divert waste from dumps and final disposal sites and to increase employment for informal waste collection workers. Educational programs are the cornerstone of awareness raising for solid waste. Many countries reach citizens using media and increasingly social media. Effective programs distribute content in varying languages and through both advanced and basic technology, such as radio and mobile phone applications. Other countries focus on schools to educate young citizens that will eventually become environmentally conscious adults[14].

Also, a substantial increase in government capacity is required to plan, budget, operate and maintain as well as monitor, inspect and enforce compliance of solid waste management infrastructure. The sustainability of an efficient and effective solid waste management system is highly dependent on human resources capacities and the ability of the regional governments to monitor and enforce the system. This is also a critical success factor for private sector participation.

Plastic and marine litter reduction

Plastic reduction, recycling and alternative policies should be considered as an issue of priority, as they can reduce the generated waste and "leakage" of such waste into the environment, rivers and ocean. The European Commission has launched its plastic policy on May 23, 2018 to target the ten single-use plastics most often found at European beaches and seas as well as lost and abandoned fishing gear, together these constitute 70% of all marine litter items. The aim of the plastic strategy is that all plastic packaging will be reusable or recyclable by 2030 and to prevent and reduce plastic marine litter from single-use plastic items and fishing gear. The strategy is foreseen to comprise of four categories to discourage single-use plastics: (i) banning certain types of plastic, such as cotton swabs, plastic plates and cutlery, and the plastic sticks on which balloons are attached; (ii) discouraging other types of plastic, such as plastic drinking cups and meal packaging, by levying additional charges; (iii) warnings on plastic categories, such as sanitary napkins, throw away wet wipes, balloons, and (iv) Extended Producer Responsibility Systems, for plastic bags, cigarette filters and the previously mentioned plastic cups and meal packaging[15].

Several other countries are currently introducing bans on certain types of single-use plastics or introducing deposit-return systems to avoid the plastic litter entering the environment, rivers, oceans and food-chain. Kenya has introduced a ban on plastic bags, California is proposing to outlaw plastic straws, unless specifically requested by customers. India is developing single use plastic regulation.

14 Kaza, Silpa, Lisa Yao, and Perinaz Bhada-Tata. 2018. What a Waste 2.0: A Global Snapshot of Waste Management to 2050. Urban Development Series. Washington, DC; World Bank. doi:10.1596/978-1-4648-1329-0. License: Creative Commons Attribution CC BY 3.0 IGO (draft).

15 http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf

In the recent G7 in Canada, five out of the seven leaders agreeing to an ocean plastic charter[16] focusing on combating ocean pollution and making all plastics recyclable by 2030, reducing single use plastics and building recycling infrastructure with innovation around more sustainable technologies.

Investigations into policies for plastic reduction and recycling and reduction of leakage of plastics into the rivers and ocean are also urgently needed in Vietnam. This will also require an increase in active research, stimulation and enforcement of plastic alternatives, investigation of the amount and types of plastics on Vietnam's beaches and where they originate from, in order to prepare effective policies of reduction and recycling as well as identify formal and informal landfills and dumpsites of waste too close to waterbodies, where substantial leakages of waste into the river occurs during the rain and floods.

Next steps

In view of: (i) the current inefficient and expensive way in which collection and transport is organized; (ii) the inappropriate waste disposal with considerable environmental impacts and mostly informal recycling with also substantial health and environmental impacts and (iii) the much higher costs for an improved system, **significant planning, and time is required for sustained efforts to achieve the goal of improving SWM services to international standards. Improvements are best implemented in a phased-approach that allows for incremental improvements that will be more affordable, creating the basis for further scaling-up in the future, and putting conditions in place for cost-effective private sector interest to operate and invest in the sector.** It will be more difficult and less successful to leapfrog from the existing simple system and very low-cost recovery levels into advanced modern and expensive solid waste management systems, without adequate planning for needed regulations, monitoring, enforcement and financial sustainability.

The necessary institutional and operational capacity building needs to precede basic infrastructure upgrading, including improvements in revenue collection. Implementation needs to be guided by detailed and preferably regional waste management master plans to develop and modernize the solid waste sector based on all the dimensions mentioned above. Private sector participation is viable when supported by appropriate legislation, regulations, monitoring, enforcement, increased waste fees and improved government capacity. The legal framework will need to establish a transparent financing mechanism with cost-recovery targets from user fees and institute a system to enforce payments.

Budget is required for detailed feasibility analysis of solid waste management technologies, skills development, capacity building and monitoring/enforcement and to prepare the roadmap/masterplan at the regional level. Considering the current low capacities, substantial training and capacity building programs will be needed in the areas of: (i) policy formulation and planning; (ii) legislation; (iii) infrastructure feasibility analysis and design; (iv) budgeting and accounting; (v) technical operation; (vi) monitoring and enforcement.

Indonesia is embarking on a national program for waste sector improvements, recognizing that sector challenges such as limited operational finance, limited operational capacity of local governments, lack of regulatory oversight and land issues pose bigger hurdles to improve waste service performances than shortages in funding for investment. It was thus decided to

16 https://g7.gc.ca/en/official-documents/charlevoix-blueprint-healthy-oceans-seas-resilient-coastal-communities/#a1

focus investment on supporting cities to improve the management of these sector issues and to prepare detailed and specific waste sector roadmaps to develop comprehensive waste improvement strategies.

For **hazardous waste** the following key next action areas and next steps are envisaged:

- Preparation of a national plan for management of industrial (hazardous) waste, distinguishing between the different types of industrial (hazardous) waste streams
- Detailed investigations of the waste from the metal exploration enterprises to be classified hazardous or non-hazardous, in particular lead-containing residues
- Establishment of proper treatment and disposal facilities for industrial waste originating from the mining industry, steel producing industry and the energy sector. The capacity of the facilities should be determined based on feasibility studies and should cover several provinces.
- Improvement of the legislative requirements to incineration facilities, including continuous monitoring of flue gas emissions and incineration temperature.
- Development of database tools for logging the hazardous waste treatment facilities in Vietnam.

The Indonesia Solid Waste Management program focuses on 46 cities that in the analytical work have been categorized as most committed and most ready to receive technical and investment support. The program has four components (1) National policy and institutional capacity, US$ 5 million; (2) Technical support program for participating cities, US$ 56 million; (3) Investment program US$ 1.1 billion public funding, expected to attract at least US$ 1.5 billion in private sector funding; and (4) Budget for Program management, progress monitoring and evaluation, US$ 15 million. In order to implement this program, the Government of Indonesia is preparing a Loan from the World Bank of US$ 100 million, of which US$ 45 million will contribute to the investments under Component 3 and the remaining US$ 55 million will be allocated for Technical Assistance under Components 1, 2 and 4, in order to direct and implement public funding and to attract private sector funding. The Loan is expected to be approved by the World Bank in March 2019.

For plastics and promotion of the circular economy, it is recommended to focus on: (i) a detailed analysis of the top 10-plastic items that are entering the oceans and are present on Vietnam's beaches; (ii) analyse successful policy actions to reduce single use plastics and promote conversion to plastics that are easier to recycle and enhance the profitability and environmental standards of recycling; and (iii) prepare a plastics action plan.

1 INTRODUCTION

1.1 BACKGROUND

Waste management in Vietnam is characterized by relatively limited performance in waste collection, treatment and disposal for almost all waste categories. Across the different waste sectors, this poor performance is linked to limited regulatory oversight, and inadequate funding for investments and operations. As a result, a large proportion of waste streams are not treated or disposed of in a controlled manner. Shortcomings in waste management are negatively affecting economic development and sustainable growth in Vietnam. Environmental and public health impacts are severe, particularly in areas with high levels of waste generation and high population density, resulting in polluted groundwater, contaminated and clogged waterways, soil pollution, spread of diseases and exposure to heavy air pollution from waste burning.

The Government of Vietnam has expressed interest in Technical Assistance to identify appropriate and long-term solutions for these Solid Waste Management (SWM) challenges, focusing specifically on large urban areas. Such efforts have concomitant environmental and health benefits, but also the co-benefits relating to greenhouse gas (GHG) emission reductions. Overall, the need for substantial improvements in waste management is well represented in the country's Green Growth Strategy and Action Plan, as well as the recently formulated Intended Nationally Determined Contributions (NDC) targets and commitments. Furthermore, large urban areas are taking the lead towards identifying an integrated strategy on Solid Waste Management. For example, Hanoi City People Committee (CPC) - led by Department of Construction (DOC) is also in the process of revising the Decision 609 by the Prime Minister on Master Plan for Integrated Solid Waste Management in Hanoi 2020, with vision towards 2030.

However, while Action Plans and Targets are prepared and Local Governments are working with investors to put in place modern technologies to reduce waste, such as composting plants and analysis into the feasibility of Waste-to-Energy plants, key policy and planning issues hamper the modernization of the solid waste sector.

1.2 OBJECTIVES AND STRUCTURE OF THE REPORT

The objective of this report, which was co-financed under the KGGTF Trust Fund, is to: support the Government of Vietnam in forecasting the future solid waste generation; assess the current situation of solid waste management; analyse distinct options and scenarios including the required investments, operational costs and impacts on waste fees and financial sustainability; and define action areas for implementation of the national strategy for solid waste management. The report provides an assessment of the current Domestic Solid Waste Management situation and establishes a minimum scenario to improve basic environmental conditions and service levels. The report then analyses progressively more advanced solid waste management scenarios to improve sector infrastructure, with the focus on waste reduction and analysis of the financial sustainability requirements.

The report analyses the different scenarios and options for solid waste sector improvements and presents the capital investments and operational costs that must be met to make these improvements in the sector, in the short to medium term. The report then analyses the fee and financing needs and the affordability impact. Based on that analysis, the report identifies the potential institutional, legal, financial or policy reforms that are needed to improve operations and make them financially sustainable, as well as exploring options and requirements for private sector involvement. The report concludes with the definition of action areas required, in order for Vietnam to successfully implement its strategy on Solid Waste Management.

Part II of the report focuses on hazardous waste management. In agreement with MONRE, the report includes an inventory and analysis of mining waste in Bac Kan and Thai Nguyen provinces, industrial waste from the steel producing industry and waste from the electronic producing industry in Thai Nguyen, sludge from wastewater treatment plants in the entire Vietnam and industrial (hazardous) waste from large industries in Binh Thuan province. The report discusses treatment and policy options, based on the analysis of the different industrial hazardous waste streams.

1.3 METHODOLOGY AND APPROACH

For the assessments and analyses of domestic solid waste management, background information and data were collected on the current waste management situation from several sources of waste and hazardous waste management strategies as well as plans collected from counterparts, meetings with stakeholders and visits to waste treatment and disposal facilities, in the respective provinces.

From the Government of Vietnam, the main counterparts relating to waste and hazardous waste management are the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Construction (MOC) - which each have related mandates on waste and hazardous management regulation and legislation; monitoring and enforcement; planning and capacity; as well as providing technical inputs and guidelines on waste management through the different stages from generation to final disposal. At the local (city) level, the counterparts that are directly responsible are the representative offices of MONRE (i.e. Departments of Natural Resources and Environment -DONREs) and MOC (i.e. Department of Construction-DOCs). The city's Urban Environment Companies (URENCOs) were engaged, given their operations within the cities and the related landfills. Data on construction and operation of modern treatment and disposal facilities are based on experience from solid waste infrastructure planning in the region and elsewhere in the world.

Planning for future waste management improvements and related investments should be based on the availability of reliable information on waste quantities, composition, generation rates, and waste density in both urban and rural areas. Currently, this information is insufficient for many reasons including a lack of an inventory of waste generators, waste generators' weak understanding of reporting methodology, no weighing of waste at most landfills, no control and analysis of information received at the provincial level, etc,. The estimates for waste quantities and forecasted quantities that are used for the modelling to obtain rough estimates for investments and operational costs for sector improvement scenarios are based on available data combined with WB's and consultants' estimates and international benchmarking. This is sufficient for the purposes of analysing sector development scenarios and providing recommendations for solid waste sector improvement. However, investment decisions need to be based on more detailed feasibility analysis, including more data collection and data verification. This report is therefore unsuitable as the basis for decisions regarding specific investments and technologies.

The Industrial (Hazardous) waste assessment prognosis for the future industrial (hazardous) waste treatment and disposal demand is based on National statistics from 2010-2015 for enterprises and the knowledge relating to the extension of the power plants in Binh Thuan Province. The identified waste types and quantities in the three provinces are based on data provided by the DONREs in the three respective provinces (Thai Nguyen, Bac Kan and Binh Thuan). The data provided, included the annual report on hazardous waste management (2016) prepared by DONRE and the waste management report for the major industrial facilities in the three analysed provinces (2016) prepared by the industrial facilities and submitted to DONRE. Additionally, data regarding the major wastewater treatment plants in the entire Vietnam, has been collected from a former World Bank study: Vietnam Urban Wastewater Review, World Bank, December 2013. A number of industrial enterprises were visited and the enterprises are listed in Annex 4. MONRE has provided data regarding the licenced hazardous waste treatment facilities in the entire Vietnam.

2 PART I: DOMESTIC SOLID WASTE

2.1 DOMESTIC SOLID WASTE MANAGEMENT IN VIETNAM: CURRENT SITUATION

2.1.1 BACKGROUND

According to the Vietnamese Standard (TCVN 6705-2009- Non-hazardous solid wastes -Classification), solid wastes are classified as follows:

- Domestic solid waste (DSW)[17]: including the solid wastes generated from households, commercial, and institutional activities;
- Construction and Demolition Solid Wastes (C&D waste): The wastes arising from construction/demolition activities;
- Normal Industrial Solid Waste (NISW): The wastes arising from processing and non-processing industries and utilities including craft villages.

Management of Domestic Solid Waste (DSW) generated by households and similar waste from commercial/ institutional/ industrial entities is characterized by two distinct elements: (i) the large waste quantities produced daily by the mega cities (especially Hanoi and HCMC) and (ii) the fine-grained and labor-intensive collection, separation and treatment system including the informal sector which dominates the market for recyclables. Strong economic and population growth, and urbanization magnify the problems and waste quantities are growing rapidly each year. Under a weak institutional framework, waste collection coverage is low, especially in rural areas. The lack of adequate control and enforcement and insufficient legislation are contributing to environmental problems which aggravate

17 There is no definition for Municipal Solid Waste (MSW) in the Vietnamese waste related legal documents.

health risks for the population. Environmental hazards also occur as a result of informal sector operations in the so-called craft villages, where substantial quantities of (hazardous) waste are generated and processed.

In addition to illegal waste disposal, the disposal of the collected waste at official waste management sites is not compliant with international good design standards and the waste sites are mainly poorly operated. Domestic waste management in Vietnam lacks the "polluter pays" principle with very low fees to be paid by households and other waste generators and at least 80% of the costs being financed by the Government.

2.1.2 INSTITUTIONAL

The administrative system in Vietnam is divided in three tiers: 1st tier: provinces and state-run cities; 2nd tier: urban districts, rural districts, provincial cities, and towns; 3rd tier: communes, wards, and townships. At provincial level, Vietnam has 5 state-run cities and 58 provinces, making a total of 63 units. The state-run cities include: two urban centres of special category (Hanoi and Ho Chi Minh) and the three cities of category I (Hai Phong, Da Nang and Can Tho). At district level there are 70 cities, 54 towns and 591 rural districts. At commune level there are 1,581 urban wards; 9,043 rural communes and 590 urban townships. People's Councils and People's Committees govern each level. All these administrative levels play different roles in solid waste management.

National level

Responsibilities for waste management at the national levels lie with MOC and MONRE. A major shortcoming at the national level, is the lack of clear accountability for specific waste management tasks, as several ministries are involved. The MOC has the highest authority in municipal solid waste (DSW) management and landfill siting but it also deals with non-hazardous industrial waste especially for landfill disposal. Its responsibilities include: (i) formulating policy and legislation; (ii) developing, and instructing on implementation of the SW treatment investment program; (iii) developing, appraising, instructing and monitoring implementation of SWM interprovincial planning; (iv) instructing, and monitoring the development and management of construction planning of SWM facilities; (v) appraising the SWM planning of state-run cities; (vi) organizing investment promotion activities, and instructing on the implementation of investments in interprovincial SWM facilities. However, MONRE is the major state authority for environmental affairs with responsibility for the development of national policies, strategies, legislation, Environmental Impact Assessment (EIA) approval and monitoring, etc., especially for hazardous industrial waste. The exact division of tasks and responsibilities between the two ministries is not clear at either the national or the local level.

Other key involved ministries are: (i) Ministry of Health (MOH) which is especially involved in medical waste. Its responsibilities in terms of waste management are assessing the impacts of solid waste on human health and inspecting and supervising hospital waste treatment activities; and (ii) Ministry of Planning and Investment (MPI) and Ministry of Finance (MOF). Regarding waste management, MPI together with the Ministry of Finance consider and provide funding and finance for other ministries, government agencies, and localities to implement waste management plans based on their annual and long-term waste management plans. Furthermore, MPI, in coordination with MOF, issues economic incentives to facilitate waste management activities; i.e. tax incentives, fixed asset depreciation incentives and land use incentives; Ministry of Science and Technology (MOST), will coordinate with MOC and MONRE to appraise the SW treatment technology that is studied and applied for the first time in Vietnam.

Local level

The implementation of state policies at the local level is the responsibility of the Provincial and City People's Committees (PPC/CPCs). Their responsibilities in waste management are to: (i) implement the state management regulations on environmental protection; (ii) approve waste treatment projects in their localities; (iii) mobilize investment capital from various sources for the construction of landfills; (iv) direct the provincial/municipal DOC and/or DONRE in carrying out the design, construction, monitoring and EIA aspects of waste treatment projects; (v) direct the provincial/municipal URENCOs in organizing waste collection, transport, and treatment activities; and (vi) approve waste collection and treatment fees based on recommendations of the provincial/municipal Department of Finance (DOF).

Furthermore, the Department of Construction (DOC) being an agency of MOC at the provincial level, is active in DSWM. Its responsibilities in DSWM and locating landfill are: (i) supporting the PPC in making decisions on waste treatment facility projects, and (ii) reporting and proposing appropriate landfill sites to the PPC for approval in coordination with DONRE.

The Department of Natural Resources and Environment (DONRE) being the local agency of MONRE plays an important role in waste management with respect to monitoring environmental quality, managing and implementing waste management policies and regulations issued by MONRE and the PPC, appraising EIAs for waste treatment projects, and coordinating with the DOC in landfill site selection, for final PPC approval.

The actual waste collection, separation, treatment, and disposal operations are carried out by state owned URENCOs (which may have different names in different cities/provinces according to their role and functions). The government strongly encourages private sector participation in solid waste collection, transportation, treatment and disposal, but always in cooperation with public organizations i.e. no privatization. Responsibilities and risks are shared between the private company and the government. This policy has been implemented in major cities in Vietnam.

Ultimately, achievements in SWM are the result of efficient and effective operations at local level. Unfortunately, many deficiencies at the local level are hampering its implementation including:

- Many DONREs have insufficient staff to carry out their regulatory monitoring and enforcement functions.
- Outside the cities and larger towns, solid waste management is often decentralized to town/district levels, but without clear guidelines and technical support from the provincial level and with insufficient allocation of resources.
- Currently the responsibility for rural DSW Management (i.e. roles, functions and accountable ministries) is not mentioned in any government decree.
- In craft villages, there is a lack of clarity on the functions and responsibilities of the three ministries that have a role in sanitation, namely Ministry of Agriculture and Rural development (MARD), MONRE and Ministry of Information and Technology (MOIT). This means that no ministry takes the lead.
- The private sector has not found it attractive to invest in the provision of DSW services due to uncertainties concerning the regulatory framework, the inconsistent enforcement of regulations, low fee levels, lack of reliable data, etc. Furthermore, ministries are not able to effectively implement the national

"privatization" policies, as these are not clear, very broad and entail complicated procedures.

- MOCs and DOCs in many provinces have prepared urban solid waste master plans but very few have been implemented, which may reflect local priorities for other sectors rather than waste management and/or lack of financing.
- National policies and strategies are available for urban solid waste management but the responsible ministries have either not issued guidelines or where guidelines, have been issued, they are inconsistent.

2.1.3 LEGISLATION AND REGULATION

A major obstacle in the legislation is the definition of "Domestic Solid Waste", as there is a lack of definition of the fractions. It is not clear if street sweeping, parks/green areas, market waste or separated fractions (waste electric and electronic equipment, packaging, batteries, etc.) or waste collected by private entities from households are included. Adoption of the internationally used definitions, such as the European Union (EU) definition is recommended.

An overview of the current legislation is given in Annex 1. The overarching law in Vietnam is the Law on Environmental Protection which emphasizes the need for waste reduction, re-use and recycling in order to achieve reduction of landfilled quantities. No specific recommendations are provided for achieving the objectives. In addition, many decrees, circulars and decisions have been adopted on specific subjects and technical regulations/standards related to aspects of solid waste management. The National Strategy on Integrated Solid Waste Management (ISWM) dated in 2009 and the recent revised National Strategy issued on ISWM dated 2018 to 2025 with a vision to 2050, indicates targets for waste separation and recycling as follows:

TABLE 2-1 Targets for waste separation and recycling

Targets (%)	2015	2020	2025
Municipal solid waste collection/recycling	85/60	90/85	100/90
Industrial waste collection/recycling	50/30	80/50	90/60
Septic tank sludge from urban area grade 2	30/10	50/30	100/50
Plastic shopping bags (* decrease compared to 2010)	40 *	65 *	85 *
Separation at source of dry recyclables	50	80	100
Non-hazardous industrial solid waste collection/recycling	80/70	90/75	100/100
Industrial solid wastes collection	60	70	100
Non-hazardous medical solid wastes collection/hazardous medical solid waste collection	85/70	100/100	100/100

Source: Decision No 2149/2009/QD-TTg dated 17/12/2009 of the Prime Minister

TABLE 2-2 Updated targets for waste separation and recycling

Targets (%)	2025
Hazardous waste	
Hazardous waste from production, services, business, craft villages and health facilities collection/treatment	100
Hazardous waste from individuals and household's collection/treatment	85
Electronic waste collection	100
Municipal waste	
Municipal waste urban special and 1st grades/other grades recycling, suitable for household collection	100/85
Municipal solid waste collection and treatment	90
Usage of environmental friendly of plastic shopping bag	100
Closed urban landfills rehabilitate/treatment/land reuse	90-95
Domestic solid waste treatment by landfill	Less than 20
Rural waste	
Rural waste from concentrated residential areas collection/treatment	80
Closed landfill at rural areas rehabilitate/treatment/land reuse	95
Spontaneous buried site treatment	100
Ordinary industrial waste	
Ordinary industrial waste from production, services, business, craft villages: Collection/ treatment	100
Ash, slag or plaster generated from power plants and chemical and fertilizer factories: recycled and reused	80
Other waste	
Construction waste from urban areas collection/recycling	100/60
Septic tank sludge from urban area	100
Waste from husbandry activities collection/treatment	80
Agricultural by-products collection/ recycling	80
Agricultural chemical and pesticide containers	100
Medical waste from health facilities and hospitals collection/treatment	100

Source: Decision No 491 /2018/ QD-TTg dated 07/05/2018 of the Prime Minister

The decrees are mostly issued at ministerial levels and deal with regional landfills, waste to energy plants, composting technologies, recycling principles, SWM strengthening in rural areas, technical codes, etc. However, no by-laws are being developed (such as for *Waste to Energy*) for implementation of the decrees. The recent decision on the revised National Strategy on Integrated Solid Waste Management (Decision 491 dated 2018) has segregated the waste more concretely, set specific targets and adopted a new view to consider waste as a resource. The Decree's Prime Ministerial priority include Waste to Energy (WtE) plants (incinerators), waste treatment centres in three economic regions (north, south, and central) and energy recovery from landfills by capturing landfill gas.

It can be concluded that the targets for 2015 have not been achieved and other targets, including those in the revised strategy, are rather ambitious and unrealistic in view of the current situation. Action areas and infrastructure requirements to achieve the targets need to be defined, taking into consideration financing arrangements for investments and cost recovery mechanisms for operations (based on fees and budget subsidies, transfers and cross-subsidies from higher payments from certain waste generators). An overall revision and cleaning up of the legislation is recommended, to enable a clear policy on future development i.e. centrally controlled responsibilities are delegated to the local authorities (centralised versus de-centralised).

2.1.4 SOLID WASTE OPERATIONS

Waste collection

Based on estimated reporting, waste collection coverage is reported at around 85% of the population in urban areas and 40% in rural areas, although actual figures could be lower. Prevailing methods of waste collection and transportation in urban areas are (i) wheeled bin system, (ii) truck collection; and (iii) the container system. For the first method, workers push wheeled collection bins through residential areas to collect solid waste. Waste is brought to waste gathering sites (transfer points) for loading into trucks and is then transported to the landfill or treatment plant. This system is labour intensive and it is causing environmental problems at the transfer points. Regarding the second method, small capacity trucks pass through the streets where possible and collect the (shopping) plastic waste bags discarded by inhabitants along the streets. Collection in rural areas is by means of trucks and waste is put directly into the truck by inhabitants. The small trucks go to transfer stations (if available) while large capacity trucks travel directly to landfill or treatment facilities. For the third method, waste is firstly disposed into plastic containers of different sizes at selected locations in residential areas, before being collected and transported by truck to the landfill or treatment plant. However, the use of containers is very limited. No special license is required for DSW collection, as is the case for hazardous waste.

Transfer points create environmental problems in the cities as trucks and carts arrive at the transfer points almost at the same time[18]. This system causes a number of problems such as: (i) traffic jams when all large trucks traffic the same spots simultaneously; (ii) In addition to the sanitation staff who gather at these points to receive the waste and transport it further, local people who make a living from the waste are also present. While waiting, people play cards and consume alcohol, causing problems for the staff and people around; (iii) each truck is attended by 5 to 10 waste pickers delaying the transfer of waste, scattering the waste around, and making the whole place and its surroundings dirty with a bad odour; (iv) the noise and exhaust gasses from the trucks and the bad odour, have a negative impact on the people living nearby.

The prevailing system in urban areas is the wheeled bin system due to the presence of many narrow streets with daily collection of waste (shopping) bags. It is estimated that 83% of collected waste is disposed of at landfills. The waste collection in rural areas occurs with a frequency of 2-3 times per week. Waste collection in cities is dominated by public organizations (URENCOs), which are also responsible for landfill operations and the management of treatment facilities.

The main problems with the current collection system are: (i) the system is rather complex often involving numerous companies in addition to the URENCOs, causing difficulty in organisation and integration of transport activities and transport routing (e.g. Hanoi: 18 units including 8 state-owned companies and 9 joint stock companies and one cooperative; HCMC has 23 state-owned companies, 5 cooperatives and 30 private companies for waste collection); (ii) lack

18 Peak hour is from 16:00 – 17:00/ 4-5 pm.

of infrastructure such as transfer stations while landfills are located at more than 40km distance (no transfer stations in Hanoi and 2 large stations in HCMC) resulting in high transportation costs; (iii) lack of guidelines and regulations to facilitate the transport system; (iv) poor management; (v) low fees and lack of capital for investments; (vi) dominating position of URENCO's which benefit from substantial financing by state funds; (vii) labour intensive resulting in high costs.

The issues of low public awareness and poor access to the collection system, or mismanagement of DSW at commune level are leading to illegal discharge of waste to the canals, lakes and the paddy fields. Separation and recycling are dominated by the financially driven informal sector involving 100-700 persons per city. Households are separating and selling to the informal sector and further to wholesalers and/or recyclers. The total separated quantity is roughly estimated at 10-15% of the collected quantity.

Solid waste disposal and treatment

Landfills. There are 660 landfills in Vietnam receiving about 20,200 tons of waste daily. Out of these 660 waste disposal sites across the country, only 30% can be classified as engineered landfills (sanitary landfilling requires daily coverage of waste, which is uncommon in Vietnam. The mega cities of Hanoi and HCMC have mega landfills covering areas of 85 ha and 130 ha respectively. Only 9% of the landfills have weighing scales and only 36% have a bottom lining. Most landfills have no compactor, gas collection, leachate treatment or environmental monitoring system and are poorly managed, mostly due to a lack of funding. The landfills are owned and operated by the URENCO. Third party waste collection companies must pay a gate fee to URENCO.

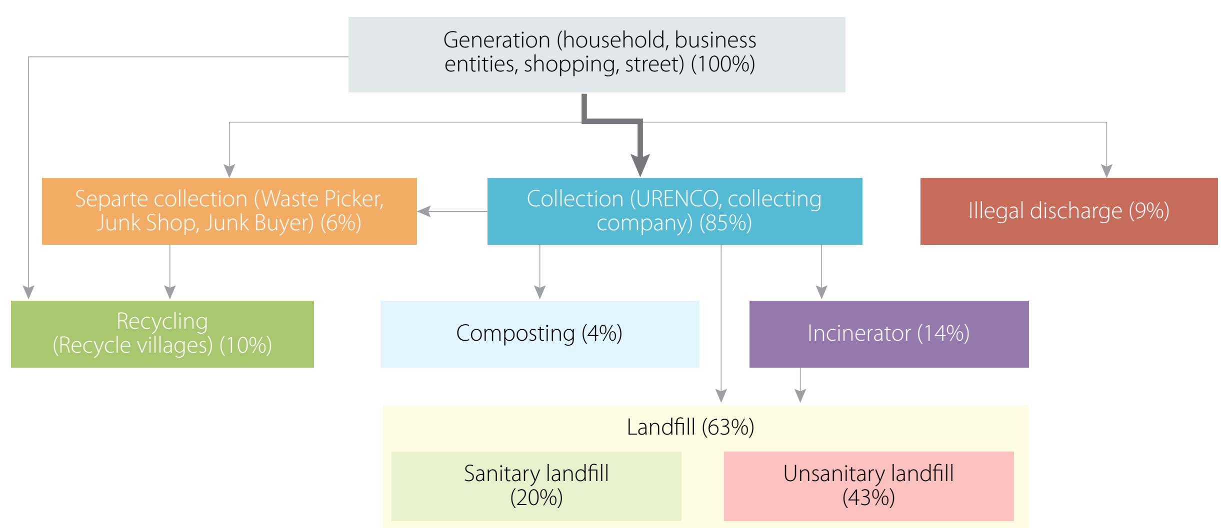
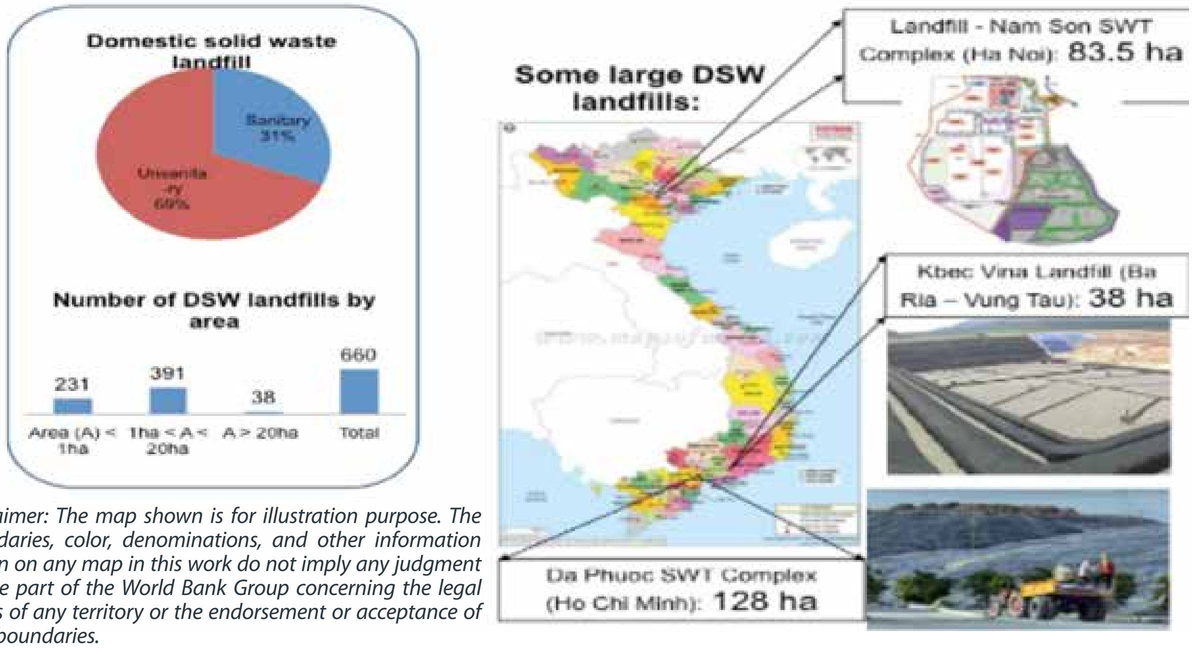


FIGURE 2-1 **Typical Waste Flow Collection**[19]

Source: WB staff and consultants, using DONRE data

19 In addition, there is 4% unaccounted in the formal collection



Disclaimer: The map shown is for illustration purpose. The boundaries, color, denominations, and other information shown on any map in this work do not imply any judgment on the part of the World Bank Group concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

FIGURE 2-2 **Location of some large landfills in Vietnam**

TABLE 2-3 **Landfills in Vietnam**

Landfills (LF)	Total LF	Sanitary LF	Non-sanitary LF	DSW received (t/y)	>20 ha	1-20 ha	<1 ha
Western North	39	12	27	224,325	1	30	8
Eastern North	85	34	51	559,525	7	44	34
Economic zone Northern	118	33	85	1,810,029	4	27	87
Economic zone of Red Delta River	72	23	49	472,693	3	49	20
Economic zone of Central	91	50	41	694,310	7	69	15
Economic zone of Eastern South, High land	113	21	92	1,008,488	5	81	27
Economic zone of Southern	33	13	20	1,793,503	8	16	9
Mekong River	109	18	91	821,828	3	75	31
Total	660	204	456	7,384,701	38	391	231

The main concerns with respect to current disposal practices are: (i) groundwater contamination having a direct impact on the water wells of the communities who are living around the landfills; (ii) contamination of surface waters through the discharge of toxic liquid wastes without adequate wastewater treatment or as a result of poor operational practices; (iii) polluting air emissions from landfill gas releases or from burning/incineration; (iv) health risks especially for the many scavengers; (v) no lining under the landfills; (vi) the landfills are attracting animals (flies, cockroaches, rats) that cause illnesses; (vii) operational procedures are poor and covering of waste is not always carried out. All kinds of papers and nylon bags are blown by the wind over the rice fields.

Treatment. Besides separation at source of recyclable fractions, an array of treatment technologies is currently in use based on imported and local technologies. No clear policy is prevailing. All treatment technologies are relatively small-scale in capacity.

About 63% of collected waste goes to landfills and 22% (approx.14,000 t/d) goes to various treatment facilities (recycling 10%, composting 4%, incineration 14%). There are about 105 waste treatment units comprised of small capacity incinerators (42%), composting plants (24%), combined composting and incineration plants (24%) and other technologies (10%). Total installed capacity is 17,600 t/d waste processing.

Recycling of mostly packaging waste is dominated by the informal sector. The amount collected and separated by the informal sector is approx. 6% of the total generated waste. The collection is mainly carried out by the informal sector before the waste enters the collection channel. In addition, the formal collection sector separates approx. 4%. Wholesalers are buying from the informal individual waste collectors, formal sector and directly from industries; they separate, bale and sell to processors. In addition to the quantities generated on the local market, substantial quantities are imported such as plastic (1.2 million t/y) and paper (1.3 million t/y). Recycling activities are mostly carried out in craft villages without the monitoring of operating practices. These activities lead to substantial pollution of air, water and land and serious health hazards for the workers. At the same time the craft villages provide substantial employment. Waste electric and electronic equipment (WEEE) waste is estimated at approx. 1-1.3 kg/cap/year or about 90,700 t/y. Electric appliances are also mostly dismantled in craft villages where they create hazardous waste problems.

Plastic bags are a specific problem as the average usage is 35 bags/household/week. The plastic bags are freely delivered by shops to the users. However, these bags are also used to deliver the waste to the collection trucks on daily basis due to absence of containers.

Vietnam has 69 small-scale waste incineration plants (less than 500kg/h), mostly located in rural areas, which substantially contribute to air pollution.

Composting technology mainly consists of foreign technologies. Processing capacity is approx. 2,500 t/d waste. There are problems with quality and demand for the compost, as farmers prefer animal manure and self-composting of agriculture waste.

WtE technology consists of biogas being produced from animal manure but not from organic household waste. Landfills are not equipped with gas collection systems and are thus not utilizing the gas to produce energy. A new plant for selected industrial waste with energy recovery was recently installed at Nam Son landfill with a capacity of 75 t/d.

2.1.5 FINANCIAL

Revenues

The revenues for public waste collection companies consist of income from fees, subsidies from the CPC and from various services such as collection and treatment of specific waste fractions. The fees for waste collection, disposal and treatment to be paid by households and the commercial entities are prepared by the People's Committees at the level of Districts, cities and towns. Fee proposals are submitted by the waste collection companies to the People's Committees of the centrally controlled Municipalities (Hanoi, Ho Chi Minh City, Hai Phong, Da Nang, Can Tho) and to the Provincial People's Committees (58) for final approval. Consequently, the fees are different in the various municipalities and in the cities and towns at the District level. All fees are based on operational costs only and exclude any amortization on investments. The People's Committees at Municipal and

Provincial level pay for the amortization costs and for any shortfall in the operational costs.

The city of Hanoi is used as an example to further illustrate cost evaluation and financing practices. It is assumed that in other cities, similar conditions may prevail. Fees excluding Value Added Tax (VAT) in Hanoi City are given in the table 2-4 below.

The average salary in Vietnam is about VND 4,845,000/month. International norms indicate an affordable fee of 1-1.5% of the average spendable income of the households. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. It can be concluded that the average fee/month for households is less than 0.5%.

The average fee/household in Hanoi is VND 26,500/household/month or 26,500x 12/1.46 tons = VND 218,630/ton (US$ 9.67/ton) comprised of VND 172,600/ton (US$ 7.6/ton) for collection and VND 46,030/ton (US$ 2/ton) for transport, assuming a waste generation rate of 1kg/cap/day and 4 persons/household. The maximum annual income from fees in 4 districts (1.3 million people) served by URENCO should therefore be 26,500x12=VND318,000/household/year x 1,300,000/4 households =VND 103,350 million/year. However, the actual income of URENCO from fees in the 4 districts is reported at VND 65,817 million/year or 64%.

The fees are a small part of the total income of URENCO Hanoi. Besides the fees for DSW services and subsidies by CPC's, income is generated from other activities such as collection of industrial waste, medical waste, construction and demolition waste, recycling, etc. A breakdown of the income of URENCO Hanoi is given in the tables below. It can be concluded that Domestic Solid Waste services constitute 59.4% of total income divided into fees (6.6%), CPC contribution (45.2%) and contracts (7.6%).

The main shortcomings in the field of revenues can be summarized as follows:

› Fees paid by households are very low i.e. less than 0.5% of spendable income while international practice is 1-1.5%.

TABLE 2-4 Fees in Hanoi City

	Client	Payment	Unit
1	**Households with a business**		
1.1	Household (HH) with restaurant, hotel, food shop, drinking stuff, construction material, vegetable, fresh stuff, HHs in craft		
a	SW amount ≤ 1m³/month		
-	Location in ward	VND/HHs/month	130,000
-	Location in village, commune	VND/HHs/month	90,000
b	SW amount ≥ 1m³/month	VND/m³ VND/ton	208,000 500,000
1.2	Institution	VND/HHs/month VND/HHs/day	50,000 3,000
2	**School, kindergarten, institutions administration offices**		
2.1	SW ≤ 1m³/month	VND/HHs/month	130,000
2.2	SW ≥ 1m³/month	VND/m³ VND/ton	208,000 500,000
3	**Other**	VND/m³ VND/ton	208,000 500,000
4	**Households**		
-	Normal HH: 5500-8000VND/pers./month= 22,000-32,000d/HH/month	VND/HHs/month	22,000-32,000
-	Poor HH: reduction 50%	VND/HHs/month	11,000- 16,000

- Waste management services are heavily subsidized by the State. Although this might be a political decision, it will hamper privatization of the sector.
- Fee collection coverage is rather low (64%).
- The accounting system with cost allocation is not transparent.

Costs

Total. The total annual costs were reported at VND 1,254,163,874,849 (US$ 55,594,000) divided into costs for waste management VND 1,065,890,660,448 (US$ 47,163,000), costs for PR/advertising VND 284,970,858 (US$ 12,610) and costs for management VND 187, 988,243,543 (US$ 8,318,000). The annual revenues are practically very similar to the annual costs because the CPC is subsidizing the shortfall.

Collection and Transport. Average collection and transport costs are VND 545,000 (approx. US$ 24)/ton including transport costs of VND 246,000 (US$ 11)/ton. An estimate of collection and transport costs is given in the table below. The estimated OPEX (US$ 22.66/t) costs are lower than the costs reported by URENCO (US$ 35/t). This could indicate in-efficiency in the current collection and transport system, especially given the high number of employees. The lack of transfer stations will lead to high transport costs.

Collection efficiency is doubtful and results in high costs. These costs include a high number of employees, which may be a political decision to reduce un-employment

Landfill. No gate fee is applied for the landfill in Hanoi as the City People's Committee is paying these costs. It is reported by URENCO that the landfill receives 4,000t/d of which approx. 1,200 t/d are transported by URENCO from the 4 districts in Hanoi with a population of 1.3 million persons. Approx. 2,800 t/d are transported in part by URENCO with the remainder being transported by 27 companies operating in greater Hanoi. These companies are not paying a gate fee. The City Peoples Committee (CPC) paid a total amount of approx. VND 140 trillion (approx. US$ 6.2 million) in 2015 to cover these costs. The gate fee is based on an operational cost estimate of US$ 3/ton plus US$ 4/m^3 leachate treatment or a total of approx. US$ 6.5/ton (3,500m^3/day leachate generation). On an annual basis this would result in a total operational cost of 365x4,000x6.5=US$ 9,490,000. The landfilling costs are estimated with operational costs totalling US$ 3.48/ton including leachate treatment. The actual costs are reported by URENCO at US$3.9/ton (VND 87,596/ton).

TABLE 2-5 **Income breakdown URENCO Hanoi (x 1,000)**[20]

Total: VND 1,307,462,369 (US$ 58,108)						
DSW	Industrial Waste	Medical waste	C&D Waste	Leachate	Recycling	Others/misc.
777,439,913 (US$34,552)	230,211,061 (US $10,186)	31,201,871 (US $1,381)	2,938,917 (US $130)	76,188,645 (US $3,371)	28,199,000 (US $1,248)	161,282,914 (US $7,136)

TABLE 2-6 **Breakdown Domestic Solid Waste (DSW) income (x1,000)**

DSW total	Fees	CPC	Contracts
777,439,913	86,665,000	591,577,646	99,197,192
	(US$ 3,852)	(US$ 26,292)	(US$ 4,408)

20 Based on exchange of US$1=VND22,600, 2015 income breakdown

TABLE 2-7 Estimated collection and transport costs (US$/ton)

Activity	OPEX	CAPEX	Total
Estimated costs			
Collection & transport:			
- Trucks	19	3.14	22.14
- Push carts	3.66	0.06	3.71
Sub total	22.66	3.2	25.85
Landfill	3.48	9.95	13.43
Total	26.14	14.15	49.28
Cost/household/month:			
- US$ (excl. VAT)	3.18	1.72	4.9
- VND	72,000	38.900	110,900
URENCO costs			
- Collection	24		
- Transport	11		
- Landfill	4		
Total	39		
Actual fee household/month			
- VND (excl. VAT)	21,000-32,000		21,000-32,000
- US$	0.9-1.4		0.9-1.4
Fee in US$/ton (excl. VAT)[1]	7-11		7-11

[1] *WB staff and consultants estimate, based on 1.07kg/cap/day and 4 persons/hh*

2.2 TECHNOLOGIES AND OPTIONS FOR SOLID WASTE SECTOR IMPROVEMENT

The overall assessment of the current situation of Domestic Solid Waste Management as described in the previous chapter shows a weak structure of solid waste collection, transport and disposal/treatment operated by poorly equipped public institutions with chronic lack of funding and insufficient reliable information on waste quantities, composition, generation rates, and waste density in both urban and rural areas.

Moving from the current system towards a modern integrated and sustainable solid waste management system at affordable costs to the government and the population will require reforms and changes both at national, regional and local level and across the different aspects of SWM, including: (i) operational practices and technical solutions, (ii) financing and cost-recovery; (iii) legislative and regulatory framework; (iv) institutional arrangements; (v) public awareness and participation; (vi) capacity building of waste institutions and government parties.

International experience demonstrates that these different aspects of SWM and building blocks as mentioned above need to be applied when modernizing and professionalising integrated solid waste management and that such steps are required prior to implementing infrastructure investments. The more detailed requirements include: (i) development of a National/Regional Solid Waste Management Strategy including the key policy decisions required; (ii) development of the regulatory and institutional framework; (iii) detailed solid waste management planning and feasibility studies at regional and local level, including establishment of (regional) waste management corporations and cost-recovery arrangements such as agreements on fee increase; and (iv) detailed design of collection and transportation systems, including transfer stations, and waste management disposal (upgrading) or treatment, including Environmental Impact Assessment and public hearings, government approvals, and financial arrangements.

A clear and realistic vision on future waste management should be developed considering financial sustainability, affordability and socio-economic conditions. Improvement of the current situation will require reforms at legal and institutional levels and will require additional improvements in investment and operational financing; system operations; and public education and participation; in both rural and urban areas. With such a broad spectrum of reform needs, priorities must be defined.

This chapter will analyse four key options/scenarios for improvements in the three agreed study areas Hanoi, Phu Tho and Hai Phong and then extrapolate the findings to the national level and assess the key constraints and recommendations on actions to be taken locally, regionally and nationwide. The options/scenarios are the following:

- Option/Scenario 1 – Basic solid waste management system
  Environmentally compliant and optimized: near 100% collection coverage in urban areas; optimize transfer and transport and sanitary and fully compliant landfills.
- Option/Scenario 2 – Waste reduction, reuse and recycling at source
  The waste reduction, reuse and recycling would be at the source, namely the household/community level in addition to the waste recycling that is currently already undertaken by the informal sector.
- Option/Scenario 3 – Lower cost waste treatment
  Low grade composting or conversion of organic waste to animal protein, production of Refuse Derived Fuel (RDF), mechanical biological treatment (all residues to landfill)
- Option/Scenario 4 – Advanced treatment technologies
  Such as Waste-to-Energy and co-incineration of waste and alternative fuels in cement plants.

For each of the scenarios/options the investment needs and operational costs are defined. The expected results in waste reduction, cost recovery requirements for public financing and waste fees, taking into account the affordability criteria for waste fees, are presented.

It is important to note that substantial improvements in waste collection and disposal practices can be made with limited investment and operational costs increases. Good examples are data collection and improvement of operational planning, disposal of waste in one location instead of multiple sites or illegal dumping, regular cleaning and simple good-housekeeping practices such was waste covering and compaction at the waste dump that can be done using existing equipment and limited staff. The section below will start with forecast of waste generation and composition for such waste planning.

2.2.1 WASTE GENERATION, COMPOSITION AND FORECAST

Planning for future waste management improvements and related investments should be based on the availability of reliable information on waste quantities, composition, generation rates, and waste density in both urban and rural areas. Currently, this information is lacking for many reasons such as a lack of inventory of waste generators, waste generators' weak understanding of reporting methodology, no weighing of waste at most landfills, no control and analysis of information received at the provincial level, etc.

The Vietnamese population is expected to increase by 18 % during the period 2015-2030. Annual DSW growth rates are estimated to be 16% for urban areas due to urbanisation. Rural areas will see an annual reduction of 3.3%. This results in an overall average of 6.6 %/y. In 2015 the waste generation is estimated at 1.19 kg/cap/day for urban areas and 0.67 kg/cap/ day for rural areas with an average of 0.8 kg/cap/day. Urban generation rates are forecast to increase in 2025 to 1.6 kg/cap/day. There are no signs that the growth rate will decrease soon.

It can be concluded that the overall collection rate is generally rather high, considering the infrastructure of the urban areas and the prevailing awareness of the population. The national waste collection coverage is reported to average 85% and 40% in urban and rural areas respectively. Waste generation rates are strongly related to economic activities and income of the population and this can vary throughout Vietnam.

Global experience indicates the link between socio-economic situation in an area and the waste generation per capita. The Gross Domestic Product (GDP) is the most important indicator for the forecast of waste generation. Based on information from the first phase of the study and the detailed information collected from the three study areas, the estimates for waste generation and collection rates in the selected years for the planning period until 2030 are presented in the table below. This data has been used for the detailed estimates on options and costs for improvements of different solid waste options in the study areas and are the basis for analysing different solid waste forecasts and sector development options, based on two years of data. For the purposes of analysis different sector development options, this is sufficient; however, for the purpose of investment decisions, more detailed feasibility study analysis and data gathering is needed. In general, there is insufficient reliable solid waste data and statistics available which is a bottleneck for proper solid waste management and investment decisions.

TABLE 2-8 **Waste generation and collection rates**

Area	DSW generation (kg/pers./day)[21]		DSW collection rate (%)	
	Year 2018	Year 2030	Year 2018[22]	Year 2030[23]
URBAN				
Hanoi	1.31	1.72	92%	100%
Phu Tho	1.31	1.72	97%	100%
Hai Phong	1.31	1.72	97%	100%
RURAL				
Hanoi	0.86	1.13	51%	51%
Phu Tho	0.86	1.13	50%	50%
Hai Phong	0.86	1.13	81%	81%

**: The reason for the high collection rate in rural areas of Hai Phong is the previously reported high collection rate. In all cases existing collection rates in rural areas are assumed to be maintained unchanged. As indicated, the figures are rough estimates for the purposes of comparing different solid waste sector development options, for the purposes of investment decisions, more specific feasibility analysis and detailed data collection will be required.*

21 Generation rates are based on figures for year 2015, extrapolated to year 2018 and 2030 respectively

22 According to information collected for Phu Tho and Hai Phong, the current collection rate is already very high in urban areas. In rural areas, the current collection rate is assumed to be around 50-51% apart from Hai Phong, where it is reported to be around 81%.

23 Collection rates in urban areas are assumed to reach 100% by year 2030. In rural areas, the current collection rates are assumed to be unchanged during the entire period until 2030.

The composition of DSW varies quite a lot from one location to another and it also has seasonal variation. In the smallest or more rural cities, the content of organic waste is higher than in the large cities. Information on generation and composition is also generally lacking for many reasons mentioned above. The current estimates for waste composition for the three projects areas under study listed in the table below are indicative of the waste composition, however there is no doubt that waste has a high organic content.

Waste composition shows a high content of organics (50-80%), a relatively low content of dry recyclables (10-25%) and a high content of inert waste (probably coming from street sweepings) of 15-38%. The energy content is low i.e. 900-1,200 kcal/kg or 3.6-4.8 MJ/kg (waste incineration or Refuse Derived Fuel production from waste needs at least 7 MJ/kg). The low content of recyclables is a result of the informal sector/private entities collecting the most valuable materials before the waste enters the waste container. No data is available, but informal collection of recyclables from households before waste enters the formal waste collection system is estimated at 10%.

There is little interest in separating the organic waste, as there is no demand for compost and thus no financial incentive. Composting of mixed DSW at central composting plants has been practised at many places in Vietnam within the last 20 years. However, in general the compost quality has been poor with a large content of contaminants, such as pieces of plastic, metal, glass etc. This has made it difficult to gain acceptance of the compost among farmers and thus made it difficult to sell the compost. As a consequence, in a number of cases, the central composting plants have been closed and the waste has simply been transported for disposal at landfills. Within the three actual study areas, this includes the Cau Dien composting plant in Hanoi and the Trang Cat composting plant in Hai Phong. Furthermore, it is reported that the Viet Tri composting plant in Phu Tho will be closed during 2018. Currently, composting of source separated (market) waste is carried out as a pilot project at the Trang Cat composting plant in Hai Phong. A critical point is that currently, compost from waste is not allowed to be used in agriculture.

A special feature of waste management in Vietnam is the waste produced in the so-

TABLE 2-9 Estimated Composition of Domestic Solid Waste (in % by weight)

Waste component	Various locations in Vietnam	Hanoi	Hai Phong	Phu Tho
Organics	50.2 – 68.9	51.9	46.0 – 49.8	70 – 75
Plastic and nylon	3.4 – 10.6	3.0	12.2 – 14.2	6 – 18
Paper and carton	3.3 – 6.6	2.7	3.8 – 4.2	No data
Metal	1.4 – 4.9	0.9	0.1 - 0.2	No data
Glass	0.5 – 2.0	0.5	0.8 – 0.9	No data
Inert	14.9 – 28.2	38.0[24]	23.9 – 24.7	25 – 30
Rubber and leather	0.0 – 5.0	1.3	0.6	No data
Tissues	1.5 – 2.5	No data	No data	No data
Hazardous waste	0.0 – 1.0	No data	No data	1 – 2
Other fractions	No data	Textile: 1.6	8.6 – 10.5	No data

Source: WB and consultants' estimates, based on data collected in study areas and data received

24 Including all particles less than 10 mm.

called craft villages (approx. 5,100) by individual households who are active in recycling. In 2015, it is reported that these individual households produced 7 million tons waste (approx. 27% of the national DSW generation) but it is unknown if this waste is categorized as DSW.

2.2.2 KEY DIFFERENT WASTE MANAGEMENT AND DISPOSAL/ TREATMENT TECHNOLOGIES

Waste collection. The prevailing existing waste collection system in urban areas is a two-stage system, with *primary collection* from households and streets by means of wheeled bins (so-called push carts). The push-carts are used for both domestic solid waste and for street-sweeping waste. The push-carts are either emptied directly into waste collection trucks at collection points – i.e. secondary collection – or where there are insufficient numbers of push-carts, they are emptied on the ground at temporary transfer points, where the waste lies until it is collected by a truck. Stationary (4-wheeled) containers with volumes of approximately 1 m^3 are used in front of large (e.g. high rise) residential buildings, offices, shops etc. These containers are also emptied by the collection trucks. Usually, collection trucks are small or medium sized compaction trucks (e.g. 5 – 15 m^3). Most often, collection trucks are used to transport the waste from the collection point to the landfill/treatment facility without further transfer to larger trucks for the transportation to the landfill.

The increase in high-rise buildings coupled with the modernization of solid waste management in the large cities, will result in the container system with containers in the size of 1 m^3 will become more applicable.

Transfer stations. The purpose of using waste transfer stations is to increase efficiency and thereby reduce the cost for transportation of collected waste to a landfill or treatment facility by transportation in vehicles with large capacity and reduced transportation cost (cost/ton/km) compared to smaller vehicles used for waste collection in the districts – and at the same time to reduce the impact from transportation on the environment. The waste flow in a system with waste transfer stations is as follows:

- Collected waste is transported to the transfer station by means of the collection vehicle (currently, relatively small capacity compaction trucks);
- Unloading of the waste into large (e.g. 30 m^3) containers at the transfer station; and
- Transportation of the large containers for emptying at the landfill or treatment facility e.g. by a large capacity transportation vehicle with trailer that can carry two large containers at a time.

Transfer stations can be established and operated only for transfer of waste to the landfill or treatment facility, but they may also be integrated in treatment facilities such as e.g. Mechanical Biological Treatment-plants in case such facilities are included in the system. All collection vehicles have an operational radius within which they are cost effective and the transfer station can be used to assist in maintaining the overall efficiency of the waste collection system. In addition, waste collected in one vehicle might also be transferred to another more effective vehicle with the objective of reducing overall operational costs. Transfer operations offer potential savings, but also involve additional waste handling.

FIGURE 2-3 Outdoor Transfer Station with compaction of waste

FIGURE 2-4 Transfer Truck and Container

When considering the high annual precipitation in Vietnam, only transfer stations with a roof should be established.

Landfilling. Landfilling is by far the prevailing waste treatment or disposal solution in Vietnam. About 60 - 70% of the waste that is collected is dumped at generally poorly designed and operated landfills. Landfills occupy valuable land and in their current state, they represent a real hazard to people and the environment. However, landfills will remain a key waste disposal method for at least the next decade, due to the fact that landfilling is the cheapest disposal option and because planning and implementation of more suitable treatment technologies is going to take time, specifically for the cost recovery and financial sustainability of more advanced and expensive technologies. Even after implementation of other waste technologies that reduce waste quantities, there will remain a substantial need for continued operation of existing landfills and for construction and operation of new landfills. As landfills cannot be fully avoided, the planning, design, construction and operation of future landfills must be carried out properly and environmental conditions and operations at existing landfills must be improved through covering of waste, treatment of leachate and collection and of use of landfill gas and improved compacting of the waste to increase the landfill capacity. The larger the size of the landfill, the more cost-effective they are.

The anaerobic decomposition of waste in landfills produces methane, a greenhouse gas 21 times more potent than carbon dioxide. Burning of waste in dumps also produces carbon dioxide as a by-product and causes substantial air pollution and health impacts from the air pollution. Landfill gas emission from landfill activities cannot be avoided. Shortly after waste has been disposed the anaerobic digestion processes begins and will result in methane emission through the waste at the tipping front or through other pathways. Efficient collection of landfill gas collection is to be achieved by placing a temporary cover at a specific disposal cell and later placing the final cover. In the initial phase of landfill operation, flaring is the only possible option for handling and treatment of the landfill gas that may be collected before the disposal cell has been closed and provided with a proper cover.

Composting. For at least the last 20 years, composting has been the prevailing treatment technology in Vietnam. Different types of composting/sorting facilities have been established with support from international donors. The main purpose of the composting has been, and still is, to recover the large organic part of the DSW and turn it into compost that can be used in agriculture as a fertiliser and for soil structure improvement. However, the early generation compost facilities operated within the last 20 years are based on composting of mixed waste, which has resulted in a poor-quality compost product, with a high content of fine particle glass, plastic and other contaminants, making it difficult to find a stable market for sale of compost. Many farmers do not want to buy or even to receive the compost for free, due to their fear of contaminating their fields, which to a large extent is correct.

FIGURE 2-5 Low quality compost made of mixed waste – with high content of various contaminants

Currently there are attempts to prepare a high-quality compost product based on source separated waste from markets and other single waste producers. This seems to be a promising way forward, although there is only limited experience with this to date. Organic household waste may also be used for compost production in the future if source separation can be introduced, which will be a challenge to implement based on international experience. Starting with the collection of large organic fractions from markets, restaurants and hotels is easier.

FIGURE 2-6 **Source separated waste for compost production in Hai Phong**

FIGURE 2-7 **High quality compost made of source separated Domestic Solid Waste in Hai Phong**

Direct production of animal protein/insect farming. Innovative technologies are coming to the market that use food waste for insect farming technologies for animal protein and also human consumption (grasshoppers, crickets, mealworms). Example is www.protix.eu which was named a Technology Pioneer in 2015 by the World Economic Forum and uses controllable, stable and scalable insect farming technologies. A success requirement for rearing and processing of insects is clean streams of non-contaminated food waste, which also requires good legislation for food no longer intended for human consumption[25] to ensure safe production of insects and derived products.

Mechanical Biological Treatment (MBT). Anything from a composting plant with a simple sieve to a more sophisticated and heavily mechanised anaerobic treatment system for solid waste is called a MBT facility. MBT systems can contain any number of configurations. Common MBT features include:

- Reception of mixed domestic waste or similar waste at a reception facility
- Initial size reduction and sorting into a fine and a coarse fraction (sometimes more than two fractions)
- The fine fraction that generally contains more organic matter undergoes an aerobic or anaerobic (or combination thereof) treatment. This is often combined with further separation (magnets, reverse slope separation, etc.). The main output from these processes is compost that can be used in agriculture, provided that the quality meets the standards. If the quality is too poor for agriculture, the compost can be used as part of daily and final cover materials on landfills.
- The coarse fraction that generally contains more plastic, wood, paper etc. (sieves, magnets, reverse slope separation, etc.). Following further separation, this fraction is used for production of RDF that is either used as fuel in waste-to-energy plants or co-incinerated together with traditional fuels in cement plants. Recyclable fractions may be further processed by the recycling industry.
- Residual waste that must be landfilled

The mechanical plant usually installed in advance of the composting may include: (i) bag splitters; (ii) shredders; (iii) grinders; (iv) magnetic separators; (v) eddy-current separators; (vi) air classifiers; (vii) screens; (viii) optical separators; (ix) ballistic separators; and (x) conveyors. Some of these steps can be replaced by manual sorting, provided that proper working conditions in terms of health and safety issues can be ensured.

The organic fractions can be treated by different technologies. In the Vietnamese context, treatment of the organic waste by aerobic composting in windrows and/or aerated static piles is recommended. This type of treatment has been practised at various plants in Vietnam for more than 20 years. Since the compost product has in general been of poor quality, measures must be taken to improve the quality – e.g. by starting collection of large organic fractions from markets, restaurants, hotels, introducing source separation of organic waste and improving the composting and screening technology applied.

(Plastics) Reduction, reuse and recycling

Internationally, critical steps are being taken to move towards a circular economy and substantially reduce the amount of waste and increase the number of products re-used or recycled. Measures include Extended Producer Responsibility (EPR) where producers are responsible to collect or take back used goods for sorting and treating their recycling. These EPRs are typically implemented for: (i) batteries, (ii) waste electrical and electronical

25 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018XC0416(01)&from=EN

equipment; (iii) packaging and packaging materials; (iv) end-of-life vehicles; (v) tyres; (vi) paper; (vii) oils; (viii) medical waste, old/unused medicines; (ix) agricultural film; (x) certain types of household hazardous waste, including (mercury containing) lightbulbs; and (xi) ink cartridges. Initial evaluations of EPR systems in EU countries indicate that EPR systems have improved waste management and recycling, there is no clear evidence (to date) of a strong positive impact of EPR on better design of products to reduce waste. Also, large differences exist in performance on EPR between countries.

Plastics and plastic waste is a particular large problem, where the large range of different (type) of plastics, colours and contamination hamper reuse and recycling. There are new and innovative plastic technologies coming to the market that large packaging manufactures are starting to employ such as new technologies to convert PET plastic back into virgin grade material for food packaging[26], but generally due to the low costs of virgin plastics, the demand for recycling plastics is insufficient. Lack of mandatory monitoring, adequate reporting and enforcement have been enormous obstacles. The EU has approved a plastic waste strategy in January 2018 with the aim for the European Industry to develop leadership in new technology and materials and transform the way plastics are designed, produced, used and recycled and develop sustainable materials. The strategy will aim to achieve the following: (i) make recycling profitable for business; (ii) curb plastic waste; (iii) stop littering at sea; (iv) drive investment and innovation; and (v) spur change elsewhere. A first foreseen step is a ban on single use plastics in 2018[27]. An action plan has been developed to implement this Strategy[28].

However, in order for such a reduction to occur and for recycling and reuse strategies to work, high gate fees for landfilling of these type of wastes or bans on landfilling of certain wastes are needed to generate the financial incentives for recycling and reuse options and the payment of reverse logistic schemes that are required for successful collection of plastic fraction and products to be collected through the EPR systems. Sufficiently high gate fees or bans for landfill disposal of waste are not currently in place in Vietnam. In addition, as the informal sector is already substantially involved in plastic and paper/carton recycling, under inappropriate environmental and health conditions, this will require involvement and special collaboration with the informal sector.

Incineration is an option used by several countries to reduce the amount of solid waste requiring disposal to landfill, and to recover energy in the form of heat and/or electricity. Countries where incineration is widely used include Germany, Switzerland, the Netherlands, Denmark and Japan; which are countries where available land for landfilling is limited. The general MSW/DSW characteristics of most of these countries include a relatively high calorific value (typically more than 9,000 KJ/kg), arising from a high paper, plastics and other combustibles content, a relatively low moisture content (less than 35%) and a low proportion of inert materials (such as rubble and dirt) and other non-combustible materials. In the Vietnamese context, DSW must be pre-treated (separated) before it makes sense to use it as a fuel in waste-to-energy plants or in cement kilns. A large part of the organic waste must be removed, which will reduce the moisture content and increase the caloric value. Therefore, in principle, when introducing incineration technologies, these are recommended to be combined with MBT/composting technologies to deal with the organic fraction.

26 http://www.ioniqa.com/unilever-to-pioneer-breakthrough-food-packaging-technology-together-with-ioniqa-and-indorama-ventures/
27 http://europa.eu/rapid/press-release_IP-18-5_en.htm
28 http://eur-lex.europa.eu/resource.html?uri=cellar:2df5d1d2-fac7-11e7-b8f5-01aa75ed71a1.0001.02/DOC_2&format=PDF

FIGURE 2-8 **Municipal solid waste incineration plant in Norway**

There are two main types of technology available for incineration of DSW:

- Mass burn incineration, which is a relatively simple and robust option. Waste is typically fed onto a slowly moving grate within the combustion chamber, with the exhausting flue gases passing through a turbine (for power generation), air pollution abatement units (to remove dust and trace contaminants), and finally through the stack to the atmosphere.
- Fluidized bed incineration, which consists of injection of pre-processed DSW into a cylindrical refractory lined shell, filled with an inert bed of either silica sand, limestone, alumina or ceramic materials which have been 'fluidized' by a stream of high pressure air. This technology is more sophisticated and requires pre-processing of the waste to achieve a uniform particle-size distribution before it can be fed into the fluidised bed furnace. Also, substantial air pollution abatement units are required to ensure that there are no negative air emissions to the environment.

Even though a certain cost reduction can be obtained by selling electricity and in some cases also the excess heat generated by incineration plants, incineration remains much more expensive than other treatment technologies and should in general not be considered a stand-alone-solution, especially not for low and middle-income countries, if the electricity feed-in fee is too low. In order to avoid air pollution by the incinerators, substantial and costly air pollution abatement units are required.

In the Vietnamese context, incineration can be considered a part of the future waste treatment solution, in combination with other less expensive technologies, such as composting of the organic fraction. This combination could result in substantial reductions in the remaining waste amounts that eventually need to be landfilled but does require significant funding to obtain technologies that do not pollute the air. Waste reduction is an important consideration for a country, where only very limited areas are left for new landfills. As with reduction, reuse and recycling options, gate fees for landfill disposal need to be sufficiently high for other more expensive treatment systems to become viable.

Cement kiln co-incineration can be much cheaper than dedicated new incineration plants as the cement plants already exist throughout Vietnam (see below).

Co-incineration in cement plants. There are cement factories in various provinces in Vietnam and they may very well form an important part of the future waste management system. Refuse Derived Fuel (RDF) produced at MBTs could be an appropriate solution for utilisation as a substitute fuel in cement kilns. The technical issues associated with utilising RDF in cement kilns are fewer compared to other co-incineration options such as use in power plants. Another advantage of use of RDF in cement kilns is the absence of an ash residue as these form part of the cement product. The cement plants have typically a number of strategies:

1. Analyse the Net Calorific Value of the RDF and pay a percentage of the price of coal based on the Net Calorific Value (Gj/ton) of coal cost
2. Analyse the waste market and charge a price which is driven by the alternatives in the market, i.e. gate fees of landfills or Waste-To-Energy-plants in the same geographical area
3. Cost plus fee; the cement plant would calculate all their cost related to feeding RDF, this would be:
   - Permit and environmental (emission monitoring, sampling and analyses of oncoming waste/RDF) cost
   - Investment in storing/feeding facilities at the cement plant
   - Quality control when RDF is arriving at the plant
   - Operational cost at the cement plant
   - Marketing & sales cost

Most of the experienced cement plants have a model which is a mix of the 3 approaches. In some countries the cement plants have built partnerships with waste management companies to get more control over the waste value chain and better control of the specifications of the RDF for the cement kiln.

Typical chemical property specifications for RDF for cement kilns are as follows: (i) calorific value (lower) (NCV) > 18.000 kJ/kg; (ii) humidity: < 15%; (iii) ash content < 12 %; (iv) sulphur < 0,5 %; (v) chlorine < 1,00 %, depending on cement process conditions this could lowered to 0,5 %; (vi) size < 30 mm, depending on feeding system and design of the calciner-inlet this could be smaller or bigger. Typically, the cement plants would increase the fee for RDF with a net calorific value of < 18.000 KJ/kg and/or a humidity or chlorine content > 0,3 %. The cement plant would also analyse the RDF to ensure that critical elements stay below threshold values, as per the table below.

In countries with high GDP, the cost of landfilling waste is so high that waste to energy/incineration plants become commercially viable. In those countries both cement kilns and waste to energy plants are applied for advanced treatment of waste. However, in countries where GDP doesn't allow drastically increased waste management fees, cement kilns offer a viable alternative.

TABLE 2-10 Elements to be analysed for RDF at cement co-processing

Elements	Values
Hg (ppm)	10
Hg + Tl + Cd (ppm)	100
As + Ni + Co + Se + Cr + Pb + Sb + Sn + V + Zn + Cu + Mn + Ba + Be (ppm)	5000
PCB	Traces or < 50 ppm

Separate financing from the **NDC Partnership Project** has been obtained to further develop the co-incineration options in Vietnam through identifying specific technical solutions and priority investments in at cement plants. The goal of these investments is to increase the use of Alternative Fuels and Raw Materials (AFR) and reduce greenhouse gas emissions through replacement of primary fuels.

Average substitution rates for Alternative Fuels and Raw Materials (AFR) is on average 39% in Europe with the highest percentage in the Netherlands is 83%. The additional study will focus on the specific waste streams that exist in Vietnam which may make a significant positive contribution to an increase in Alternative Fuels and Raw Materials (AFR) supply to cement plants. Key waste streams that are suitable for AFR are: (i) municipal waste, specifically *plastic fraction* (Refuse Derived Fuel); (ii) sewage sludge; (iii) agricultural waste; (iv) scrap tires, (v) POP containing pesticides; and (vi) PCBs.

The study will analyse the caloric value of the waste streams, potential volumes available, emission reductions that can be achieved for usage of different streams of AFR and make price comparisons with the current costs for primary fuels (costs/ton and costs/Gcal). The study will also describe the key bottlenecks and success factors needed for full market development of AFR and the potential for private sector involvement. The study will be presented in late 2018.

FIGURE 2-9 **Further WB analysis on potential and requirements for increased AFR use**

Typically, there is a large range in terms of payment, from the low end where the supplier of the RDF receives US$ 30/ton from the cement plants to RDF suppliers having to pay US$ 30/ton to the cement plants, depending on market conditions, the quality of the RDF and the price of the alternative primary fuel.

The presence of the cement industry in Vietnam means that waste incinerators may not be necessary if a competitive cost-effective market for co-incineration can be developed. The major advantage of cement kilns is that they already exist in Vietnam, are quite tolerant to waste composition and offer environmentally safe and economical solutions. However, it must be ensured that cement plants are equipped with proper flue gas cleaning systems before RDF is co-incinerated. Some cement plants in Vietnam already have sufficient capacity to use RDF that could be produced at the proposed MBTs.

2.2.3 FOUR DISTINCT SOLID WASTE MANAGEMENT IMPROVEMENT OPTIONS/SCENARIOS

Waste generation is expected to more than double in the next 15 years, even more in the urban areas. Rapid urbanization and economic growth will result in further substantial growth of waste generation. Growth figures between 1%-5% are forecasted for the major urban areas. Vietnam will need to substantially increase it strategy for and financing of gradual and more discrete improvements of its solid waste collection, transport and disposal/treatment in order to improve solid waste management service to internationally acceptable minimum standards without environmental impacts and move towards more advanced and capital-intensive waste treatment systems, in a financially sustainable manner.

The Government has to make informed policy decisions on the improvement strategy for the sector which will involve not only the technologies to be integrated into the solid waste management system, but also the regulatory, institutional and financial implications that need to be addressed to achieve environmental and financial sustainability. Policy decisions will also need to consider the affordability of waste fees and the public's willingness to pay, which in turn depends on the public's satisfaction with service levels.

This report analyses four distinct solid waste management improvement options/scenarios with the aim of analysing: the investment and operational costs needs for each of the options; the expected results in waste reduction; and the requirements for cost recovery for each option, in terms of increases in waste fees and remaining financing gaps. As indicated, the four scenarios are:

Option 1: Basic optimized solid waste management system

The system includes improvement of collection and transportation, incl. use of transfer stations prior to transportation to proper sanitary and fully environmentally compliant landfills. Apart from sorting of recyclables during the collection and transportation process, the system does not include any further treatment and/or reduction measures. Thus, this option does not assume any changes to the current informal recycling system and the current 10% recycling rate is assumed to be maintained unchanged.

Within the planning period to 2030, in this study, all people living in urban areas will have access to the waste collection system (100%). A number of transfer stations shall be established in order to improve the efficiency of the transportation system. All collected waste will be taken for disposal at proper landfills.

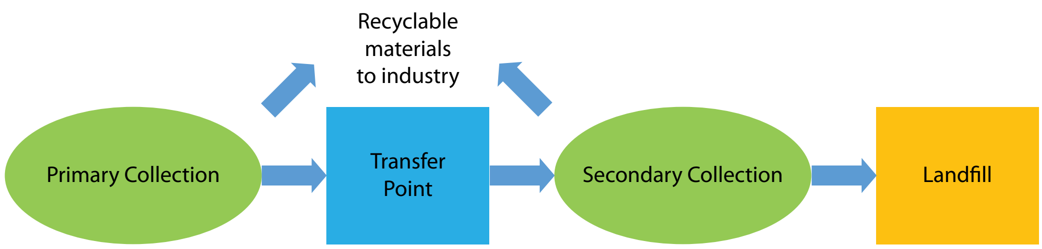


FIGURE 2-10 **Elements included in Option 1**

Option 2: Waste reduction, reuse and recycling at source

In this option, the current recycling rate (during collection by the informal sector) is foreseen to increase gradually from the current 10% to 24% in 2020. In addition, option 2 includes some additional sorting of recyclables at households, growing from 1% in 2018 to 13% in 2030. Apart from sorting of recyclables at households and during the collection and transportation process, the system does not include any further treatment and/or reduction measures.

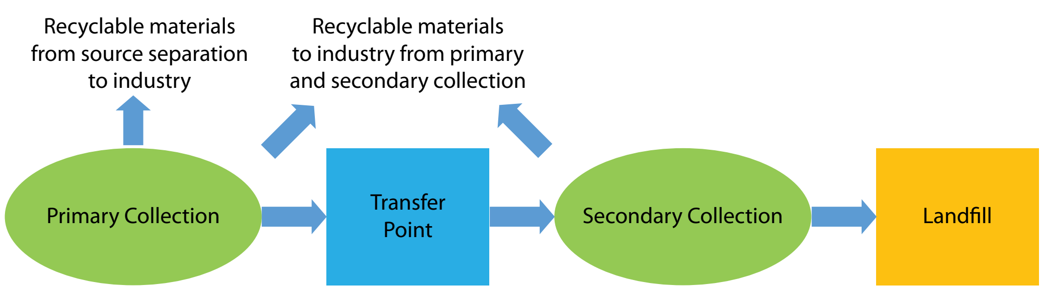


FIGURE 2-11 **Elements included in Option 2**

Within the assumed planning period to 2030, all people living in urban areas will have access to the waste collection system. A number of transfer stations shall be established in order to improve the efficiency of the transportation system. All collected waste will be taken for disposal at proper sanitary and fully environmentally compliant landfills.

Option 3 – Low Cost Waste Treatment

In addition to option 1 as described above, option 3 includes MBT plants for sorting, composting and RDF production. Furthermore, MBT plants include transfer stations for transfer of residual waste for cost-effective transportation of residual waste to landfills and of RDF to the cement industry. Within the assumed planning period to 2030, all people living in urban areas will have access to the waste collection system. Pushcarts (and containers in front of high rise buildings) are emptied by compaction trucks that transport the waste to a number of MBT-plants located at various places within the service area, thus limiting the transport distance for the collection trucks. At the MBT-plants waste is sorted mechanically and manually into the following fractions:

- High quality recyclable materials for the recycling industry (dry fraction, large particle size)
- Organic fraction for a compost plant located within the MBT-plant (wet, small/medium particle size)
- Mainly small particle fraction residual waste for landfill disposal (e.g. gravel, soil, dust, glass etc.)
- RDF made from the remaining combustible fraction. RDF is assumed delivered to the cement industry at zero costs or to incineration facilities.

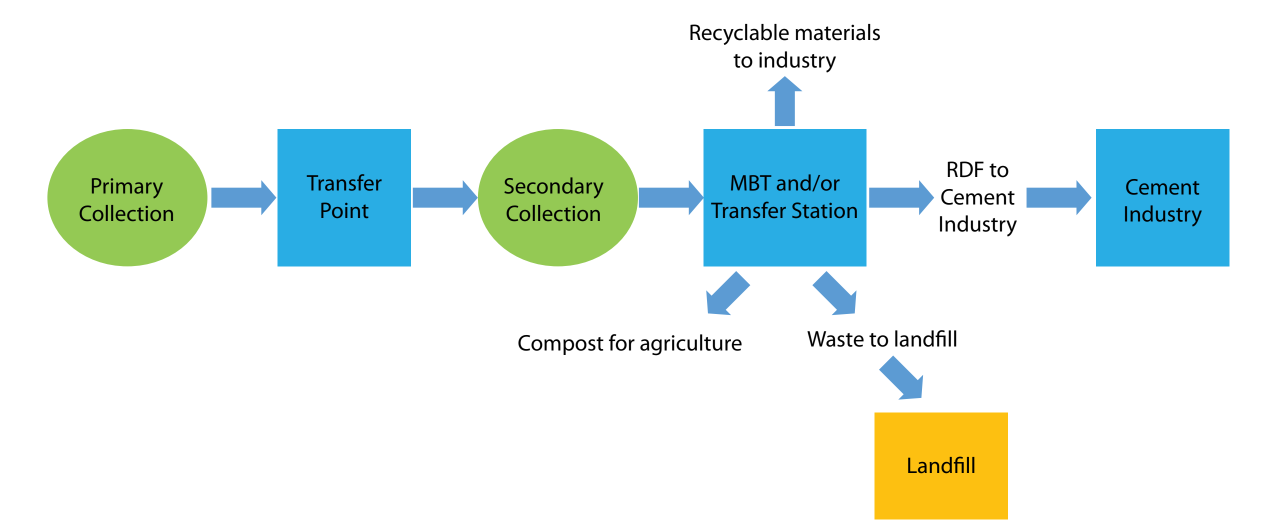


FIGURE 2-12 **Elements included in Option 3**

Option 4 – Advanced treatment technologies

Option 4 includes MBT plants for sorting, composting and production of RDF as fuel for Waste-to-Energy/incineration plants. Further, MBT plants include transfer stations for transfer of residual waste for cost-effective transportation of residual waste to landfills. Within the assumed planning period to 2030, all people living in urban areas will have access to the waste collection system. Pushcarts (and containers in front of high rise buildings) are emptied by compaction trucks that transport the waste a number of MBT-plants located at various places within the service area, thus limiting the transport distance for the collection trucks. At the MBT-plants, waste is sorted mechanically and manually into the following fractions:

- High quality recyclable materials for the recycling industry (dry fraction, large particle size)
- Organic fraction for a compost plant located within the MBT-plant (wet, small/medium particle size)
- Mainly small particle fraction residual waste for landfill disposal (e.g. gravel, soil, dust, glass etc.)
- RDF made from the remaining combustible fraction. RDF is assumed to be incinerated at on-site Waste-to-Energy plants.

No other types of "advanced treatment technologies" are considered, as they will be at least as expensive as incineration in Waste-to-Energy plants.

Costs of different Solid Waste Management and Treatment/Disposal technologies

As a basis for the analyses of options for improvements in each of the three study areas, the information provided in Table 2-11 below has been used to develop technical solutions, capacities and unit costs based on international benchmarks that are generally used for such equipment, in the Asia region and localized for costs in Vietnam. The landfill costs are based on detailed designs (for comparable size sanitary landfills) in Armenia (2012 and 2015), Georgia (2014) and Kyrgyzstan (2013-2014). The relevant cost level for Vietnam has been considered in the breakdown presented in Table 2-12.

Costs for incineration plants are based partly on general experience from recent plants at different places in Europe (e.g. Denmark, Sweden, Ireland). Prices are adapted following consideration of actual costs for an incineration plant assignment for an investor in Sri Lanka (2017-2018). The costs of landfilling do not include the specific location costs, such as costs of land, resettlement and expropriation, which would need to be determined as part of specific master planning/road map/feasibility study analysis.

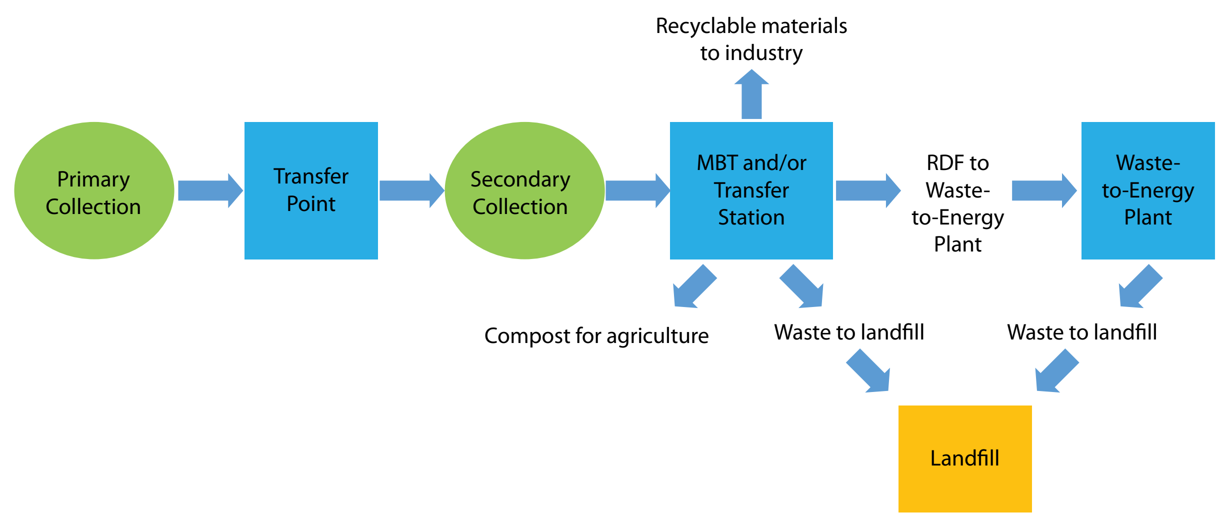


FIGURE 2-13 **Elements included in Option 4**

TABLE 2-11 **Equipment, facilities and applicable costs included in the options analyses**

Item	Description	Local prices / costs
Push carts/ containers	Wheeled bins and containers used for primary collection from households and for street sweeping waste. Volume: 0.75 m^3 - 1 m^3, Density: 300 kg/m^3, 5 loads per day. Lifetime: 5 years	Price: 500 US$/unit. O&M costs: 1,500 US$/ year incl. worker's salary.
Transfer point	Paved areas at the curb sides for parking of full and empty pushcarts. In average 1 point is estimated per 1,000 persons. Lifetime: 20 years	Price: 5,000 US$/unit. O&M costs: 100 US$/ year
Collection truck	15 m^3; 7.5 ton; 4 trips per day; 90% availability; 27 t/d; Lifetime: 5 years.	Price: 100,000 US$/unit. O&M incl. salaries: 64,000 US$/year
Transfer station	200,000 t/y. Lifetime: 20 years	Price: 7,000,000 US$/unit (incl. trucks and equipment). O&M incl. salaries: 1.4 mln US$/year
MBT-facility	200,000 t/y, Lifetime: 20 years	Price: 45,000,000 US$/unit. O&M: 6.0 mln US$/y
Incinerator	1000 t/d (two lines of 500 t/d). Lifetime: 20 years	Price: 150,000,000 US$/unit. O&M: 8 mln US$/y (assuming income from electricity sale at $0.10/kWh)
Landfill	2 mln tons capacity	Price: 10,000,000 US$/unit. Total O&M: 2 mln US$/y

In order to further illustrate the assumed construction costs for landfills and incinerators in the Vietnamese context, the estimated breakdown of construction costs for these facilities are presented in Table 2-12 below.

Total investment costs per city have been estimated on a basic unit price approach. This means that for e.g. MBT, to calculate investment costs, the total volume of waste to be treated in a specific city with MBT technology in scenarios 3 and 4 has simply been divided by the unit capacity (200,000 t/y) to determine number of units and thus total investments required for the city. This approach has been used to estimate investments for all system elements: collection and transport equipment, transfer stations, sanitary landfill capacity and treatment facilities. In this manner a first rough indication of investment levels can be determined. This approach also allows for comparison of investment levels as well as operation costs between development

TABLE 2-12 **Example on breakdown of estimated costs for establishment of incinerators and landfills**

Item	Description	Construction costs
Incinerator (2 lines of 500 t/d each)	Civil Works	30,000,000 US$
	Administrative buildings	1,000,000 US$
	Other costs incl. fees, consultancy, management	3,000,000 US$
	M&E (Mechanical and Electrical equipment)	95,000,000 US$
	APC (Semi-dry Air Pollution Control equipment)	20,000,000 US$
	Grid connection	1,000,000 US$
	Total:	**150,000,000 US$**
Landfill (2 mln tons capacity)	Civil Works	8,300,000 US$
	Administrative buildings	400,000 US$
	Fixed equipment (incl. weighbridge)	100,000 US$
	Moveable equipment	1,200,000 US$
	Total:	**10,000,000 US$**

scenarios. Further refinements have not been made and would need to be part of city level master planning or roadmap preparation for implementation purposes.

The unit costs approach implies some simplifications. For instance, for MBT, each unit of 200,000 ton/year includes (i) a materials recovery facility (MRF) to separate waste streams and screen out recyclables; (ii) a composting plant; and (iii) equipment to bring RDF to the necessary specification for use as fuel in cement kilns or incinerations. In reality, MBT plants will vary in size across the city and these three functionalities may be split across various plants to gain economies of scale. Integration of transfer stations in the MBTs have been assumed, as this is beneficial. Some main simplification in estimation of operational costs (operations and maintenance) is that revenues from electricity feed-in fees (estimated at US$ 0.1/kWh) are considered as a reduction in overall annual operating costs for WtE plants. Also, the operation costs of MBTs and MRFs per investment unit are all-in overall costs that are based on very limited revenues from sales of recyclables, compost or RDF. These assumptions, to some extent, result in conservative estimates of costs per ton. However, in many systems, the revenues from the sale of these products hardly outweighs the additional logistic costs (additional handling, transport and delivery costs), and sales of recyclables only have a limited impact on reducing overall system costs.

For the incineration facilities, or Waste to Energy Plants, a moving grate technology has been assumed rather than fluidized bed technology for the investment costs. While fluidized bed technology is a cheaper technology, it also causes operational problems and there is a need to add coal to maintain the temperature requirements. Detailed master planning and feasibility study analysis will be required for cities/provinces analysing their waste sector improvement plans to determine the feasibility and suitability of specific solid waste infrastructure and technologies.

2.3 SOLID WASTE MANAGEMENT OPTIONS/SCENARIOS FOR SELECTED CITIES

2.3.1 HANOI

This section includes an analysis of the existing solid waste management situation in Hanoi and it presents the four different waste strategy options/scenarios with analysis of waste flows, costs and affordability which can be used by authorities for (financial) planning of solid waste management improvements.

Current waste management Hanoi

Hanoi covers an area of about 335,000 hectares and with a population of about 7.5 million. The city is listed among 17 capital cities with the biggest area worldwide. There are 30 administrative units at district and town level, and 584 communes, wards and towns. Hanoi is one of the fastest growing cities in Vietnam. By 2015, the city's urbanization rate was 47.55%, 1.42 times higher than the national average urbanization rate (33.40%) and with an annual growth rate of 1.89%. The number of inhabitants in urban districts was 3,699,500 persons (49.2% of total population). The number of inhabitants in rural districts was 3,823,100 persons (50.8% of total population). For the period 2018 until 2030, for the purposes of strategy and (financial) planning of solid waste management improvement options, urban population is forecasted to grow and the rural population will continue to decrease, as shown in Table 2-13 below.

TABLE 2-13 Forecast on population and waste generation for Hanoi

Item	Year 2016	Year 2018	Year 2030	Comments
Urban population (No.)	3,699,500	4,286,272	7,618,293	Increasing (4-7%/year)
Rural population (No.)	3,823,100	3,523,369	2,158,803	Decreasing (4% /year)
Total population (No.)	7,522,600	7,809,641	9,777,095	Annual growth: 1.89%
Urban DSW generation (t/y)	1,687,897	2,046,284	4,773,577	Increasing
Rural DSW Generation (t/y)	1,144,254	1,103,439	887,366	Decreasing
Total DSW generation (t/y)	2,832,151	3,149,723	5,660,943	Annual growth: 4.75%
Urban DSW gen. (kg/cap./day)	1.25	1.31	1.72	
Rural DSW gen. (kg/cap./day)	0.82	0.86	1.13	
Total DSW gen. (kg/cap./day)	1.03	1.10	1.59	

Key characteristics and problems related to the current waste collection, transportation and treatment system are:

Primary collection. As indicated, prevailing methods of waste collection in Hanoi (as well as in other urban areas) are: (i) wheeled bin/ pushcart system, (ii) direct truck collection; and (iii) container system. Pushcarts are used in narrow streets where waste trucks have difficulty to pass. In those areas waste collection workers push wheeled collection bins through residential areas to collect solid waste that is put out by small (shopping) plastic bags discarded by residents along the street, as depicted in the figure below.

FIGURE 2-14 Push carts are widely used for primary waste collection and for street sweeping waste

Waste collection by means of push-carts is carried out at least once per day and street-sweepers clean the major roads several times per day. Thus, in general, inhabitants are used to a high waste collection service, where their waste is collected frequently – even if they just throw it in the streets or place it in (small plastic shopping) bags at the kerbside. This system is however very labour intensive, and it is causing environmental problems at the transfer points (see below).

For the *direct truck* collection, small capacity trucks pass through the streets and collect the small (shopping) plastic waste bags discarded by inhabitants along the streets. The small trucks go to transfer stations, while large capacity trucks travel directly to landfill or treatment facilities.

For the *container system*, waste is firstly disposed of into containers of different sizes at selected locations in residential areas, before being collected and transported by truck to the landfill or treatment plant. Stationary (4-wheeled) containers with volumes of approximately 1 m^3 are used in front of large (e.g. high rise) residential buildings, offices, shops etc. Use of *containers* is very limited, but particularly used in the areas with high rise buildings as a necessary modernization. There is a strong need for replacement of existing as well as new collection equipment.

Transfer points in streets. Full pushcarts are placed at various vacant areas on sidewalks/ pavements. The push-carts are either emptied directly into waste collection/transport trucks at collection points – i.e. *secondary collection*– or where the number of push-carts is insufficient, they are emptied on the ground at temporary transfer points, where the waste will lie until it is collected by a truck and is then further transported to the landfill or treatment plant. These kerbside transfer points are pictured in the figure below.

FIGURE 2-15 **Transfer point with push carts to be emptied by secondary collection trucks**

There are substantial environmental problems at the transfer points in the residential neighbourhoods and therefore, there is a need for well-planned and properly designed and constructed transfer points at kerbsides, where push-carts and containers can be placed that are then emptied into the secondary collection/ transport trucks and then can be more easily cleaned from excess solid waste.

Secondary collection. Usually, collection trucks are small or medium sized compaction trucks (e.g. 5 – 15 m^3), as larger trucks are more expensive and not suitable for driving on narrow roads. Most often, collection trucks are used to transport the waste from the collection areas to the landfill/treatment facility without further use of a larger transfer station where waste is compacted and transferred into larger trucks to optimize the transport costs to the landfill or other waste treatment facilities. No special license is required for DSW collection as is the case for hazardous waste. Many collection trucks are outdated and must be replaced by new/additional compaction trucks.

Recycling. It is estimated that about 10 % of the DSW is currently recycled. Recycling activities are clearly dominated by the private, informal sector. Collection of recyclable materials, mainly packaging waste, is typically carried out by the informal sector before the waste enters the formal collection channel. Some materials are separated at source and other fractions are separated by collection workers during collection and transportation. Wholesalers buy from the informal waste collectors and in some cases from the formal sector (URENCO's). These informal waste collectors separate, bale and sell the products to the processing industry. Processing of recyclables are to a large extent carried out in craft villages without proper monitoring of operating practices. These activities lead to substantial pollution of air, water and land and serious health hazards for the workers. At the same time, craft villages provide considerable employment.

FIGURE 2-16 **Typical small compaction truck used for secondary collection and transportation**

FIGURE 2-17 **Separation and packing of recyclables in the street in Hanoi**

Disposal/treatment. Nearly all waste that is collected is transported to Nam Son landfill for disposal. The landfill, which has a total area of approximately 84 ha., is highly overloaded and there is an urgent need for new disposal capacity. Until 2-3 years ago, compost plants were operated at Cau Dien and Kieu Ky. However, the operation was stopped as the compost could not be sold due to poor quality.

Institutional. A large number of companies/entities are involved in waste collection, transportation and treatment in Hanoi. The service providers consist of 31 entities working completely independent from each other, including the following: (i) urban districts: URENCO Hanoi (collecting waste from 4 downtown districts) and 10 local entities – Joint Stock Companies (collecting waste from the remaining urban districts); (ii) rural districts: 20 local entities – Joint Stock Companies (collecting waste from all rural districts)

Financial. The average fee for households in Hanoi is VND 26,500/household/month, corresponding to VND 6,625/cap./month. The people's committee is responsible to collect the fee from the households. The fee collection efficiency is reported to be 64%, which is rather low.

Assessment of four options/scenarios for swm improvements in Hanoi

The four different options/scenarios for modernization of Solid Waste Management are detailed below for Hanoi. Each option/scenario includes: a forecast of the amount of waste that can be expected in the period 2018-2030; the solid waste infrastructure that would be needed to deal with the waste flows in the different options/scenarios; the corresponding impacts on investment and operational costs; and the accompanying implications for waste fee increases and the remaining financing gaps.

Option/Scenario 1 - Basic Solid Waste Management System

As indicated previously, for the purposes of supporting (financial) planning of solid waste management modernization, the collection rate for urban areas is planned to increase from the current 92% to 100% while the rural collection rate will remain unchanged to allow solid waste management in urban areas to remain a priority. Under this option, the waste collected in Hanoi would increase from the current 2.5 million tons per year to 5.2 million tons per year in 2030. In this scenario, which focuses on provision of a modern and fully environmentally complaint basic solid waste system, the recycling percentage is not expected to increase from the 10% which is currently collected by the informal and private sector. Since the amount of waste generated would increase substantially under this option, the current 250,000 tons per year of recycled waste would increase to about 522,000 tons per year in 2030. In this scenario, a large amount of waste would need to be landfilled, doubling from the current 2.2 million tons year to 4.7 million tons per year in 2030. The waste flow collected, recycled and landfilled in option/scenario 1 is presented in Table 2-14 below for the planning period from 2018 to 2030.

The development of the waste flow within the planning period is further illustrated in Figure 2-18 below. The figure shows that the collection rate under option 1 would gradually increase to close to 100%. In this option/scenario waste amounts for landfill disposal continue to grow rapidly during the planning period.

TABLE 2-14 Option/Scenario 1 – Waste flow forecast Hanoi for 2018 – 2030

Item	Year 2018	Year 2030
Option 1: Basic Solid Waste Management System		
Collection rate – Urban (%)	92	100
Collection rate – Rural (%)	51	51
Collection Total (t/y)	2,453,051	5,226,134
Recycling (%)	10	10
Recycling (t/y)	245,305	522,613
Residual waste for landfill (%)	90	90
Residual waste for landfill (t/y)	2,207,745	4,703,520
Residual waste for landfill - Accumulated (t)		43,578,676

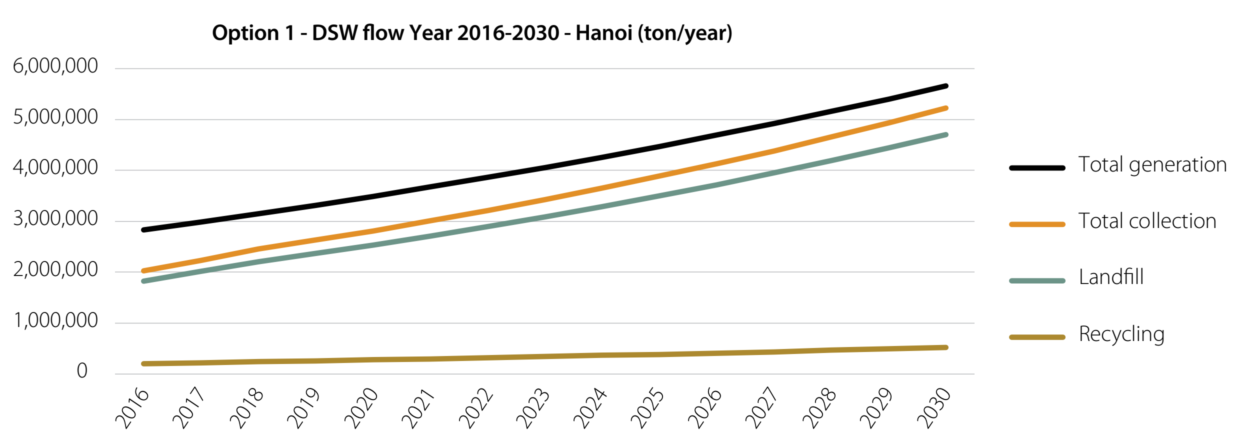


FIGURE 2-18 Option/Scenario 1 – Basic Solid Waste Management System – waste flow for Hanoi (ton/year)

A substantial number of new pushcarts/ containers and transfer points will be needed in the streets of Hanoi. A total of 8,700 new transfer points and 12,500 new pushcarts and containers will be needed by the year 2030. There will also be a substantial need for modern transfer stations outside the Hanoi city centre where waste can be compacted and transferred to larger transport trucks in order to substantially reduce the transport costs. Some 22 landfills with a capacity of 2 million tons will be needed as this option/scenario focuses on the costs of upgrading the collection equipment and disposal infrastructure (landfills) and the accompanying operational costs necessary to improve the Solid Waste Management System to service levels and standards that do not cause environmental and health impacts. The necessary equipment and facilities for handling waste in Hanoi for the period until 2030 are listed in Table 2-15.

If land areas are available for landfill with capacities of greater than 2 million tons, the number of landfills needed and the costs of landfilling would be reduced, as economies of scale would apply. However, it is difficult to find land in general and due to the environmental impacts of the current landfill operations, there is significant public opposition to landfilling. The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11.

The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal required in each of the four-year periods to 2030 are presented in Table 2-16.

The costs demonstrate the investments associated with the upgrading of the collection equipment (pushcarts, containers), and the costs of disposal infrastructure (sanitary and environmentally compliant landfills) including transfer stations to optimize transport to the landfill. This option/scenario does not include more advanced solid waste treatment infrastructure. These costs exclude the costs of land acquisition, resettlement, and taxes as these would need to be determined as part of a specific feasibility study analysis. The estimated operational and maintenance costs are presented in Table 2-17.

TABLE 2-15 **Option 1, Hanoi – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Planning basis
Option 1: Basic Solid Waste Management System			
Transfer points in streets (No.)	5,758	8,719	1 per 1000 persons
Pushcarts /containers (No.)	5,974	12,727	0.75 m^3; 1 m^3, 5 loads/day.
Compaction trucks for collection (No.)	249	530	15 m^3, 7.5 t; 4 trips/d
Transfer stations (No.)	13	27	Capacity each: 200,000 t/y
New landfills needed (2 mln tons capacity each)	2	22	

TABLE 2-16 **Option/Scenario 1– Basic Solid Waste Management System: Total investments estimated for Hanoi for Solid Waste Collection and Disposal (US$)**

Option/Scenario 1	2018-2021	2022-2025	2026-2030	Total
Collection	40,968,000	15,760,000	32,620,000	89,348,000
Disposal	162,000,000	98,000,000	149,000,000	409,000,000
Total	202,968,000	113,760,000	181,620,000	498,348,000

TABLE 2-17 **Option/Scenario 1 – Annual operation and maintenance costs Hanoi for Solid Waste Collection and Disposal (US$)**

Option/Scenario 1	2018-2021	2022-2025	2026-2030	Total
Collection	113,120,000	146,682,000	240,878,000	500,680,000
Disposal	109,200,000	177,600,000	346,600,000	633,400,000
Total	222,320,000	324,282,000	587,478,000	1,134,080,000

The investments in collection are high in the first four years due to the supply of new pushcarts/containers and trucks. Gradually, in subsequent years, both transfer stations and the substantial number of new and environmentally sanitary landfills that are required for the large increase in waste generation, are rolled out in this option/scenario. In the event that full cost recovery is introduced and that all costs are to be covered by normal residents, the average costs per person will be as shown in Table 2-18 below.

TABLE 2-18 **Option 1, Hanoi – Total average costs per person per year**

Option/Scenario 1: Basic Solid Waste Management System	US$/person/year	US$/ton	VND/person/year	VND/ton
Total investments and reinvestments	3.78	9.17	85.861	208,300
Total operation and maintenance costs	9.51	23.0	215,968	523,500
Total annual costs	13.30	32.22	301,829	731,800

The average current fee per household in Hanoi is VND 26,500/household/month or 26,500x 12 months/1,46 tons of waste per household per year = VND 218,630/ton (US$ 9.67/ton), based on an average waste generation rate of 1kg/cap/day and 4 persons/household.

The average salary in Vietnam is VND 4,845,000/month. International norms indicate that waste fees remain affordable for waste management services when they are below 1%-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household and with an average of 4 persons per household in Vietnam, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 48-72% of the average costs as presented above.

If the fees were to be increased to what is considered to be an internationally affordable level, this would still leave an annual financing gap of VND 83,804-156,479 per person per year, US$36.5- US$68 million per year.

Option/Scenario 2 – Basic Solid Waste Management System with waste reduction, reuse and recycling at source

As in the first option/scenario, collection rate for urban areas is planned to increase from the current 92% to 100% while the rural collection rate remains constant. All provisions for a modern and fully environmentally complaint basic solid waste system are also part of this scenario. While in the first option/scenario, the recycling percentage is not expected to increase from the 10% currently collected by the informal and private sector, in this scenario the recycling during collection is forecasted to grow from 12% to 24%. In addition, due to separation at the household level, (separation at source), additional waste recycling of 13% is forecasted in 2030.

This leads to an increase in recycling materials from the current 322,732 tons per year to about 1,827,139 tons per year in 2030. In this scenario, much less waste needs landfilling, from 2.1 million tons per year in the beginning to 2.7 million ton per year in 2030. The waste flow collected, recycled and landfilled in option/ scenario 2 is presented in Table 2-19 below for the planning period from 2018 to 2030.

The development of the waste flow within the planning period is further illustrated in the Figure 2-19. Because of sorting/recycling at source, the collection rate does not reach 100% of the waste generation. Furthermore, although recycling has been increased, the amounts for landfill disposal continue to grow during the planning period.

The necessary equipment and facilities for the handling of the waste in Hanoi for the period to 2030 are listed in Table 2-20.

TABLE 2-19 Option/Scenario 2 – Waste flow forecast Hanoi for 2018 – 2030

Item	Year 2018	Year 2030
Option 2: Waste reduction, reuse and recycling at source		
Collection rate – Urban (%)	92	100
Collection rate – Rural (%)	51	51
Collection Total (t/y)	2,426,959	4,546,736
Sorting/recycling at source (%)	1	13
Sorting/recycling during collection (%)	12	24
Recycling in total (t/y)	322,732	1,827,139
Residual waste for landfill (%)	87	60
Residual waste for landfill (t/y)	2,104,227	2,719,597
Residual waste for landfill - Accumulated (t)		31,951,064

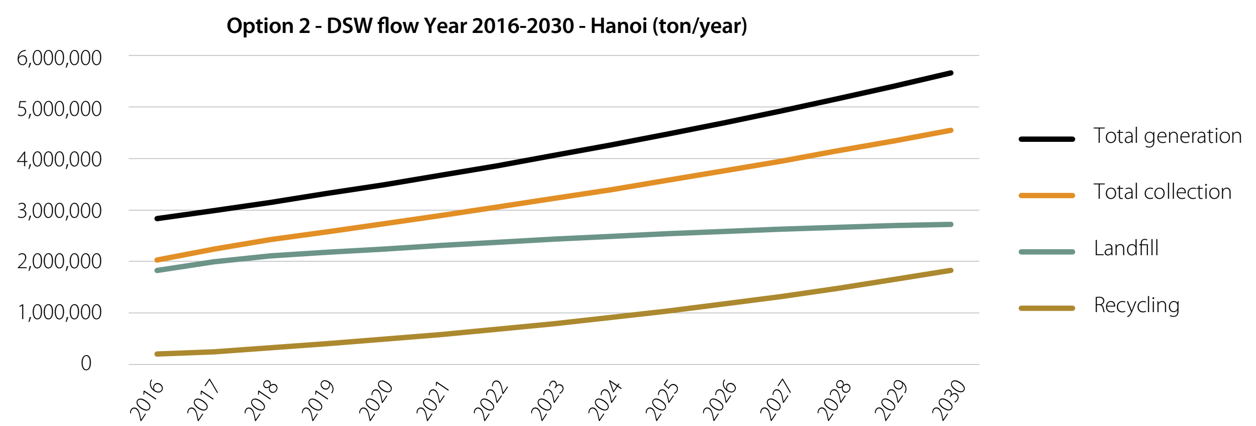


FIGURE 2-19 Option/Scenario 2 – Basic Solid Waste Management System and recycling– waste flow for Hanoi (ton/year)

TABLE 2-20 **Option 2, Hanoi – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Comments
Option 2: Waste reduction, reuse and recycling at source			
Transfer points in streets (No.)	5,753	8,719	1 per 1000 persons
Pushcarts/containers (No.)	5,910	11,073	0.75 m^3; 1 m^3; 5 loads/day.
Compaction trucks for collection (No.)	246	461	15 m^3, 7.5 t; 4 trips/d
Transfer stations (No.)	13	23	Capacity each: 200,000 t/y
New landfills (2 mln tons capacity each)	2	16	

The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11. The investments in equipment and facilities that are required for modernization of the collection, transport and disposal needed in each of the four-year periods until 2030 is presented in the Table 2-21 below.

The costs for collection are comparable to those under the first option/scenario, while the costs for disposal[29] are substantially lower. This is particularly since the number of landfills required is reduced in this scenario. However, separation of waste by households is difficult to achieve and only limited success has been achieved in many countries, despite decades of effort and outreach. Separation of waste, especially paper and plastic from commercial and institutional establishments and organic waste from kitchens, restaurants, markets and hotels can be more attractive, since the quantities available for recycling are larger. The estimated operational and maintenance costs are presented in Table 2-22 below but do not include the Vietnam specific costs for outreach, public awareness and education required to make recycling at source a potential success.

TABLE 2-21 **Option/Scenario 2 – Basic Solid Waste Management System and Recycling: Total investments estimated for Hanoi for Solid Waste Collection and Disposal (US$)**

Option/Scenario 2	2018-2021	2022-2025	2026-2030	Total
Collection	39,600,000	13,493,000	27,195,000	80,289,000
Disposal	155,000,000	71,000,000	95,000,000	321,000,000
Total	194,600,000	84,493,000	122,195,000	401,289,000

TABLE 2-22 **Option/Scenario 2 – Annual operation and maintenance costs Hanoi for Solid Waste Collection and Disposal (US$)**

Option/Scenario 1	2018-2021	2022-2025	2026-2030	Total
Collection	110,242,000	137,218,000	214,553,000	462,013,000
Disposal	105,000,000	159,200,000	283,000,000	547,200,000
Total	215,242,000	296,418,000	497,553,000	1,009,213,000

29 These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis.

TABLE 2-23 Option 2, Hanoi – Total average costs per person per year

Option/Scenario 2: Basic Solid Waste Management System and recycling	US$/pers./year	US$/ton	VND/pers./year	VND/ton
Total investments and reinvestments	3.16	8.26	71,806	187,700
Total operation and maintenance costs	8.55	22.34	194,168	507,000
Total annual costs	11.72	30.60	265,974	694,700

As in the first scenario, investments in collection are high in the first four years due to the supply of new pushcarts/containers and trucks. In subsequent years transfer stations are gradually rolled out and still there is a need for a substantial increase in new and environmentally sanitary landfill capacity. Where full cost recovery is introduced and all costs are to be covered by normal residents, the average costs per person are shown in Table 2-23.

The average salary in Vietnam is VND 4,845,000/month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 55-82% of the average costs as presented above.

If the fees were increased to what is considered to be an internationally affordable level, this would still leave an annual financing gap of VND 47,949-120,624 per person per year or US$21- US$52 mln per year.

Option 3 – Low cost waste treatment

As per the first option/scenario, the collection rate for urban areas is planned to be increased from the current 92% to 100% while the rural collection rate remains constant. All provisions for a modern and fully environmentally complaint basic solid waste system are also part of this scenario. In this scenario, Mechanical Biological Treatment facilities are employed to mechanically separate the household waste, in order to separate the organic fraction for composing and a Refuse Derived Fuel fraction that is suitable for co-processing at cement plants (or waste-to-energy plants).

This leads to an increase in recycling materials from 245,147 tons per year to about 1,068,744 tons per year in 2030; 1,045,227 tons of compost is produced per year in 2030, together with 1,556,081 tons per year of Refuse Derived Fuel that can be used in the cement industry. In this scenario, much less waste needs landfilling, from 1.0 million tons per year in the beginning to 1.6 million ton per year in 2030. The waste flow that is collected, recycled and landfilled in option/scenario 3 is presented in Table 2-24 next page for the planning period from 2018 to 2030.

The development of the waste flow within the planning period is further illustrated in Figure 2-20 below. Amounts for landfilling are limited due to the significant positive impact from composting and the use of RDF in cement plants.

Similar to previous scenarios, a substantial number of new pushcarts/containers and transfer points would be needed in the streets of Hanoi and mechanical biological treatment facilities would be required. In this option/scenario, only 9 landfills with a capacity of 2 million tons would be needed. The necessary equipment and facilities for handling of the waste in Hanoi for the period to 2030 are listed in Table 2-25 next page.

TABLE 2-24 **Option 3 – Waste flow forecast Hanoi for 2018 – 2030**

Item	Year 2018	Year 2030
Option 3: Low cost waste treatment		
Collection rate – Urban (%)	92	100
Collection rate – Rural (%)	51	51
Collection Total (t/y)	2,451,474	5,226,134
Recycling (%)	10	20
Recycling (t/y)	245,147	1,068,744
Compost (%)	2	20
Compost (t/y)	49,029	1,045,227
Other treatment, RDF for cement industry (%)	44	30
Other treatment, RDF for cement industry (t/y)	1,078,649	1,556,081
Residual waste for landfill (%)	44	30
Residual waste for landfill (t/y)	1,078,649	1,556,081
Residual waste for landfill - Accumulated (t)		17,379,614

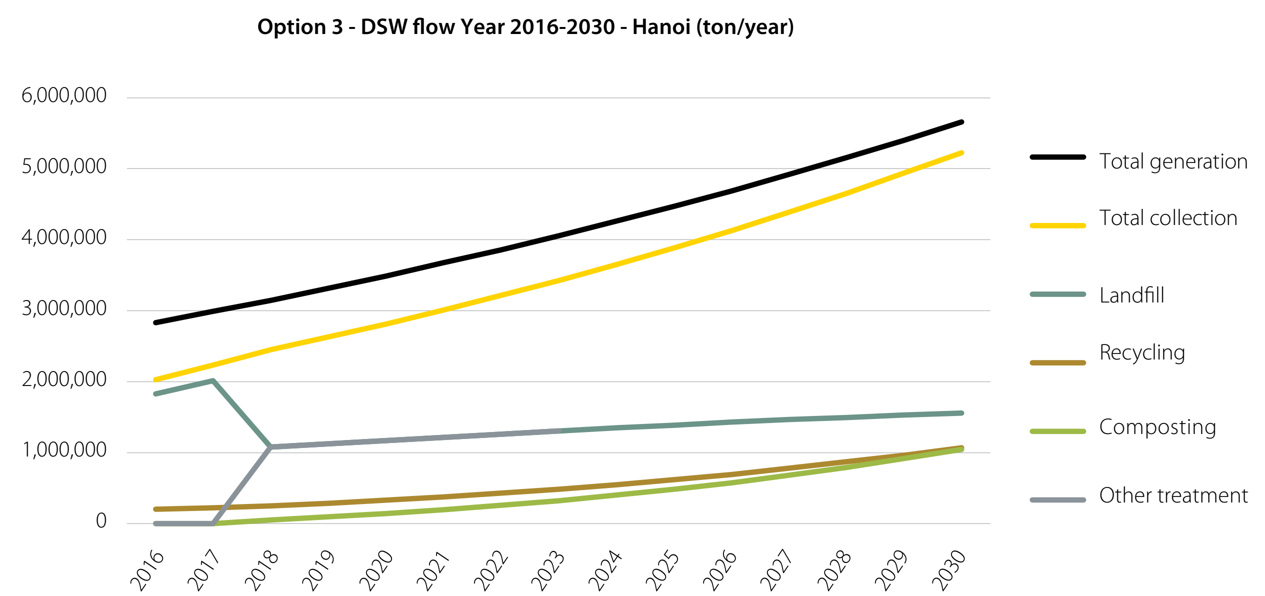


FIGURE 2-20 **Option/scenario 3 – Low cost waste treatment – waste flow for Hanoi (ton/year)**

TABLE 2-25 **Option 3, Hanoi – Necessary equipment and facilities – Year 2018 and 2030**

Item	Year 2018	Year 2030	Comments
Option 3: Low cost waste treatment			
Transfer points in streets (No.)	5,753	8,719	1 per 1000 persons
Pushcarts (No.)	5,970	12,727	0.75 m^3, 1 m3, 5 loads/day.
Compaction trucks for collection (No.)	249	530	15 m^3, 7.5 t, 4 trips/d
Transfer stations (No.)	0	0	Capacity each: 200,000 t/y
MBT facilities	13	27	Capacity each: 200,000 t/y
Other treatment, RDF for cement industry (No.)	0	0	Existing cement factories
New landfills (2 mln tons capacity each)	2	9	

The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11. The transfer stations in this scenario are integrated in the MBT facilities. The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal required in each of the four-year periods to 2030 are presented in Table 2-26 below.

The costs for collection are comparable to those under the first option/scenario, while the costs for disposal/treatment[30] are substantially higher due to the mechanical biological treatment systems. The advantage is that there is a substantially reduced need for landfilling and landfills. The estimated operational and maintenance costs are presented in Table 2-27 below.

As in the first two scenarios, investments in collection would be high in the first four years, due to the number of new pushcarts/ containers and trucks that would be required.

In subsequent years, the mechanical biological treatment stations are gradually rolled out, which are the main costs driver, as the new and environmentally sanitary landfill capacity required in this option/scenario is lower (only 9 landfills). Where, full cost recovery is introduced and all costs are to be covered by normal residents, the average cost per person are shown in Table 2-28 below.

The average salary in Vietnam is VND 4,845,000/ month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates an income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 24-35% of the average costs, as presented above.

TABLE 2-26 Option/scenario 3 – Low cost waste treatment: Total investments estimated for Hanoi for Solid Waste Collection and Disposal (US$)

Phương án/Kịch bản 3	2018-2021	2022-2025	2026-2030	Tổng số
Thu gom	40.968.000	15.760.000	32.620.000	89.348.000
Xử lý	750.000.000	210.000.000	345.000.000	1.305.000.000
Tổng số	790.968.000	225.760.000	377.620.000	1.394.348.000

TABLE 2-27 Option/scenario 3 – Annual operation and maintenance costs Hanoi for Solid Waste Collection and Disposal (US$)

Option/Scenario 3	2018-2021	2022-2025	2026-2030	Total
Collection	113,103,000	146,682,000	240,878,000	500,663,000
Disposal/ treatment	366,000,000	480,000,000	790,000,000	1,636,000,000
Total	479,103,000	626,682,000	1,030,878,000	2,136,663,000

TABLE 2-28 Option 3, Hanoi – Total average costs per person per year

Option/Scenario 3: Low Costs Treatment	US$/person/Year	US$/Ton	VND/person/Year	VND/ton
Total investments and reinvestments	8.86	21.48	201,193	487,543
Total operation and maintenance costs	18.20	44.10	413,108	1,001,067
Total annual costs	27.06	65.58	614,301	1,488,610

30 These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis.

If the fees were to be increased to a level that is considered to be internationally affordable, this would still leave an annual financing gap of VND 396,276 - 468,951 per person per year, US$172- US$204 mln per year.

Option 4 – Advanced treatment technologies

As in the first option/scenario, the collection rate for urban areas would be planned to increase from the current 92% to 100% while the rural collection rate would remain constant. All provisions for modern and fully environmentally complaint basic solid waste systems are also part of this scenario. In this scenario, Mechanical Biological Treatment facilities are employed to mechanically separate the household waste, in order to separate the organic fraction for composing and a Refuse Derived Fuel fraction that is then incinerated in dedicated Waste-to-Energy plants.

As in the third option/scenario, this leads to an increase in recycling materials from 245,147 tons per year to about 1,068,744 tons per year in 2030; 1,045,227 tons of compost would be produced per year in 2030 and 3,285,000 tons per year of materials would be incinerated in Waste-to-Energy Plants. In this scenario, there is still substantial amount of waste to be landfilled at the start (2.1 million tons per year), but this reduces to only 320,000 tons per year in 2030. The waste flow collected, recycled and landfilled in option/scenario 3 is presented in Table 2-29 below for the planning period from 2018 to 2030.

The development of the waste flow within the planning period is further illustrated in the Figure 2-21 below. Amounts for landfilling are limited due to the significant positive impact from composting and the incineration in Waste-to-Energy plants.

TABLE 2-29 Option 4 – Waste flow forecast – Year 2018 and 2030 for Hanoi

Item	Year 2018	Year 2030
Option 4: Advanced treatment technologies		
Collection rate – Urban (%)	92	100
Collection rate – Rural (%)	51	51
Collection Total (t/y)	2,453,051	5,660,943
Recycling (%)	10	20
Recycling (t/y)	245,147	1,068,744
Compost (%)	2	20
Compost (t/y)	49,029	1,045,227
Waste-to-Energy (%)	1	63
Waste-to-Energy (t/y)	36,500	3,285,000
Residual waste for landfill (%)	87	6
Residual waste for landfill (t/y)	2,126,272	319,913
Residual waste for landfill - Accumulated (t)		11,056,129

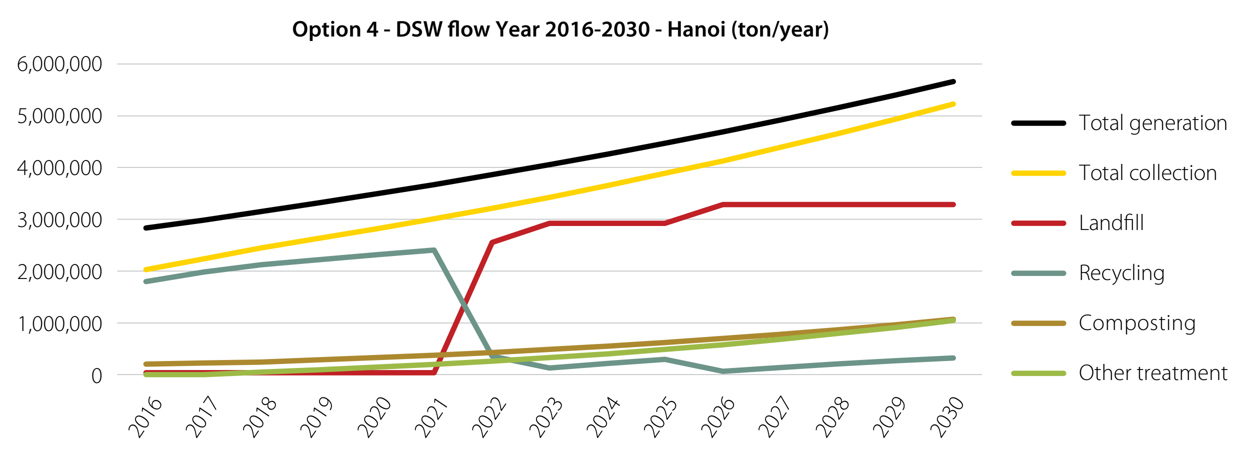


FIGURE 2-21 Option 4 – Advanced treatment technologies – waste flow for Hanoi (ton/year)

The necessary systems and facilities for handling of the waste in future are listed in Table 2-30.

The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11. In this scenario, the transfer stations are integrated into the MBT facilities. The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal required in each of the four-year periods to 2030 are presented in Table 2-31 below.

The costs for collection are comparable to those under the first option/scenario, while the costs for disposal/treatment[31] are substantially higher due to the waste to energy plants. While there is the advantage is that there is substantial less need for landfilling and landfills, there is less advantages compared to scenario 3 where the RDF is provided to the cement plants. The estimated operational and maintenance costs are presented in the Table 2-32.

TABLE 2-30 Option 4, Hanoi – Necessary equipment and facilities – Year 2018 – 2030

Item	Year 2018	Year 2030	Comments
Option 4: Advanced treatment technologies			
Transfer points in streets (No.)	5,753	8,719	1 per 1000 persons
Pushcarts/containers (No.)	5,970	12,727	0.75 m³, 1 m3; 5 loads/day.
Compaction trucks for collection (No.)	249	530	15 m³, 7.5 t; 4 trips/d
Transfer stations (No.)	0	0	Capacity each: 200,000 t/y
MBT facilities	13	27	Capacity each: 200,000 t/y
Waste-to-energy plants (No.)	0	9	Capacity each: 1,000 t/day
New landfills (2 mln tons capacity each)	2	6	

TABLE 2-31 Option/scenario 4 – Advanced waste treatment: Total investments estimated for Hanoi for Solid Waste Collection and Disposal (US$)

Option/Scenario 3	2018-2021	2022-2025	2026-2030	Total
Collection	40,968,000	15,760,000	32,620,000	89,348,000
Disposal	770,000,000	1,390,000,000	465,000,000	2,625,000,000
Total	810,968,000	1,405,760,000	497,620,000	2,714,348,000

TABLE 2-32 Option/scenario 4 – Annual operation and maintenance costs Hanoi for Solid Waste Collection and Disposal (US$)

Option/Scenario 4	2018-2021	2022-2025	2026-2030	Total
Collection	113,103,000	146,682,000	240,878,000	500,663,000
Disposal/treatment	376,000,000	734,000,000	1,134,000,000	2,244,000,000
Total	489,103,000	880,682,000	1,374,878,000	2,744,663,000

31 These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis.

As in the first two scenarios, investments in collection would be high in the first four years due to the supply of new pushcarts/ containers and trucks. In subsequent years, the mechanical biological treatment stations and waste to energy plants would be gradually rolled out, which are the main costs driver as the new and environmentally sanitary landfill capacity required is considerably less in this option/scenario (only 6 landfills). If full cost recovery is introduced and all costs are to be covered by normal residents, the average costs per person will be as shown in Table 2-33 below.

The average salary in Vietnam is VND 4,845,000/ month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 16-25% of the average costs as presented above.

If the fees were increased to what is considered to be internationally affordable, this would still leave an annual financing gap of VND 665,450 – 738,125 per person per year, US$289- US$321 million per year.

Planning for future waste management improvements and related investments should be based on the availability of reliable information on waste quantities, composition, generation rates, and waste density in both urban and rural areas. Investment decisions need to be based on more detailed feasibility analysis, including additional data collection and data verification. A key recommendation for provinces and cities that are planning infrastructure investments with or without the private sector is: to **budget the funds required for a detailed feasibility analysis of solid waste management technologies, skills development, capacity building and monitoring/enforcement and to prepare the roadmap/masterplan at the regional level, as the basis for selecting specific investments and technologies.**

Required institutional and operational capacity building needs to precede even basic infrastructure upgrading, including improvements in revenue collection. Considering the current low capacities, substantial training and capacity building programs will be needed in the areas of: (i) policy formulation and planning; (ii) legislation; (iii) infrastructure feasibility analysis and design; (iv) budgeting and accounting; (v) technical operation; (vi) monitoring and enforcement. Sustainable private sector participation is viable when supported by appropriate legislation, regulations, monitoring, enforcement, increased waste fees and government capacity. The legal framework will also need to establish a transparent financing mechanism with cost-recovery targets from user fees and institute a system to enforce payments.

TABLE 2-33 Option 4, Hanoi – Total average costs per person per year

Option/Scenario 4: Advanced Treatment Technologies	US$/person/Year	US$/Ton	VND/person/Year	VND/ton
Total investments and reinvestments	15.85	38.41	359,823	871,943
Total operation and maintenance costs	23.07	55.90	523,652	1,268,944
Total annual costs	38.92	94.31	883,475	2,140,886

2.3.2 PHU THO

This section includes the analysis of the existing solid waste management situation in Phu Tho. Four different waste strategy options/ scenarios are presented with analysis of waste flows, costs and affordability which can be used by authorities for (financial) planning of solid waste management improvements.

Current waste management in Phu Tho

Phu Tho province is a mountainous and northern midland province with a total area of 3,520 km^2 divided into 13 districts, towns and cities, including 2 urban areas (Viet Tri City and Phu Tho Town) and 11 districts (Phu Ninh, Thanh Ba, Ha Hoa, Doan Hung, Lam Thao, Cam Khe, Thanh Thuy, Yen Lap, Thanh Son, Tan Son and Tam Nong). Phu Tho has 1,381,710 inhabitants in the province, divided across the individual districts, city and town as shown in Table 2-34 below.

TABLE 2-34 Population in Phu Tho

No.	Area	Population
1	Viet Tri City	198,002
2	Phu Tho Town	71,065
3	Doan Hung District	108,519
4	Ha Hoa District	108,203
5	Thanh Ba District	112,604
6	Phu Ninh District	98,782
7	Yen Lap District	86,778
8	Cam Khe District	133,464
9	Tam Nong District	78,644
10	Lam Thao District	103,449
11	Thanh Son District	123,170
12	Thanh Thuy District	78,326
13	Tan Son District	80,704
	Total:	**1,381,710**

Population growth in Phu Tho has been assumed to be similar to Hanoi and on that basis Table 2-35 below shows the distribution between urban and rural population. The growth and the waste generation rates per capita in rural and urban areas have been calculated for the period 2018-2030.

Institutional

The entities involved in solid waste management in the province are:

- **Viet Tri Urban Environmental Services JSC,** responsible for domestic waste collection and transportation for urban wards; and waste transportation for rural communes in Viet Tri City. The company is also in charge of tree maintenance, urban lighting, sewerage, cemetery services and collecting the environmental fee. The company has a total staff of 447 out of which 260 are working with solid waste management.
- **Phu Tho Waste Treatment Joint Stock Company (JSC),** responsible for domestic waste treatment for Viet Tri City, Phu Tho

TABLE 2-35 Forecast on population and waste generation for Phu Tho

Item	Year 2016	Year 2018	Year 2030	Comments
Urban population (No.)	258,543	399,321	1,161,581	Increasing (5-21%/year)
Rural population (No.)	1,123,167	1,035,111	634,222	Decreasing (4%/year)
Total population (No.)	1,381,710	1,434,432	1,795,803	Annual growth: 1.89%
Urban DSW generation (t/y)	117,960	190,638	727,840	Increasing
Rural DSW Generation (t/y)	336,164	324,173	260,694	Decreasing
Total DSW generation (t/y)	454,124	514,811	988,534	Annual growth: 5.12%
Urban DSW gen. (kg/cap./day)	1.25	1.31	1.72	
Rural DSW gen. (kg/cap./day)	0.82	0.86	1.13	
Total DSW gen. (kg/cap./day)	0.90	0.98	1.51	

Town, Lam Thao and Phu Ninh District. The waste is treated at an outdated composting plant. The sorted waste that cannot be composted is disposed at a temporary dumpsite within the area of the composting plant. Phu Tho Waste Treatment JSC is also in charge of industrial waste treatment through its facilities at Tram Than Waste Treatment Complex site. The company signs contracts directly with the enterprises that generate industrial waste. The company has 80 staff.

Waste collection

According to the information obtained from DONRE, the collection rates were as follows in 2016: (i) In urban areas: Waste collection and treatment has been carried out in 299 out of 313 residential areas, covering 95.5%; and (ii) In rural areas: Waste collection is carried out at 630 of 1,579 residential areas, covering 40%.

Urban areas: People discharge domestic waste at the collection points along the roads and central areas. Collection workers collect the waste on a daily basis by pushcart and transfer the waste to (mainly small capacity) compaction trucks. Urban waste collection and transport is assigned to URENCO in Viet Tri, Phu Tho town and to 8 district public works management boards.

Rural areas: In Viet Tri, Phu Tho town, Lam Thao, Phu Ninh, URENCO, and Public Works Management Board collect waste using (mainly small) compaction trucks and transfer the waste to the Treatment Plant. In other districts, the Public Works Management Boards collect waste or communes treat waste on the spot by burning or carry out uncontrolled dumping.

In addition to the system above, Lam Thao Superphosphat & Chemical Joint Stock Company carries out waste collection, transportation and treatment for seven residential areas of Lam Thao district. Within the entire province, domestic waste is to some extent collected and transported by means of compaction trucks, other general trucks, and pushcarts. However, some districts still have to use small trucks, farm vehicles or other rudimentary vehicles due to lack of equipment. The equipment used in the province in 2016 includes: (i) 24 waste compaction trucks (2.5-7 tons); (ii) 14 vans (from 1.5 to 7 tons); (iii) 22 farm vehicles; and (iv) 1,090 pushcarts, motorized vehicles, tricycles and other rudimentary vehicles. This equipment is divided between 2 urban environmental companies, 8 public works management boards, 29 cooperatives and 92 sanitation teams for waste collection and transport.

Waste Sorting and Treatment

The Viet Tri Waste Treatment Plant was established in 1998 by KfW funds. It included a composting plant using Chinese and Vietnamese equipment, applying forced aeration technology; and a small incinerator. The incinerator broke down in 2005 and since then no incineration has taken place in the province. The initial capacity of the facility was 20-30 tons/day. In 2004, the capacity was upgraded to 60 tons/day. Since 2013, the waste is being received at a rate of 200-250 tons/day.

Once received, the waste is ground and sorted by sieving. 50% of the small-size waste is composted. About 40% of waste is retained as a compost product and the remaining 10% is disposed of in the landfill. The total compost capacity is about 20 tons compost/day. The compost is made from mixed DSW and contains quite a lot of contaminants, such as plastic, metals, glass etc,. For this reason, it is hard to sell the compost, which is only accepted by farmers for specific use in fields for growing of cassava, tea and sugar canes. For these reasons, DONRE reports that the existing compost plant, operated by Phu Tho

Waste Treatment JSC, will soon be closed. Most of the waste received at the Viet Tri Waste Treatment plant is disposed at an unlined and uncontrolled dumpsite located within the area of the composting facility.

Since 2017, the province has planned to establish an industrial waste treatment facility for hazardous waste treatment and domestic waste treatment. The facility will consist of a 500 tons/day incinerator with electricity generation and medical waste treatment facilities, located in Tram Than Commune, Phu Ninh District, Phu Tho Province. The total investment capital required for the two phases of planned investment is US$ 90 million (equivalent to VND 2,051 billion) and the construction of the facility is planned to be completed by end of 2018.

Following commissioning of the 500 tons/day incinerator, the district landfill will be converted into a transfer station and the existing Viet Tri Waste Treatment Plant in Van Son will be closed. All waste collected at the districts will then be transported to the Tram Than incinerator. The distance between the districts and the Tram Than treatment site varies from 42 km (Viet Tri City) to over 80 km (Tan Son district).

The project investor is Au Viet Company, a Joint-Venture between a Vietnamese company and a Chinese partner. The equipment to be provided is of Chinese origin. During project preparation, the PPC delegated a team to conduct a study tour to China. The detailed technology appraisal has not been conducted yet. Under the agreement between the investor and PPC, the treated unit price is 16 US$/tons and the province guarantee a supply of 500 tons/day. That means the investor is entitled to invoice 500 tons/day for a received volume of up to 500 tons/day. For any excess volume, the company will invoice 16 US$/tons on top of the guaranteed amount. The PPC is also supporting the investor to establish an agreement with the Ministry of Trade on feeding the electricity output into the national grid.

Financial

In urban wards, Viet Tri URENCO staff collect fees at households. In rural areas, the company authorizes the heads of villages to collect the fee. The company pay the fee collectors 10% of collected amount. The domestic waste treatment fee for Phu Tho Waste Treatment Joint Stock company is 272.5 VND/kg[32].

The fees collected in 2016 totalled 7 billion VND and the estimate for 2017 is 10 billion VND. It is estimated that the fees collected cover 1/3 of the total operation costs. The remaining 2/3 is subsidized by the Provincial Peoples Committee.

In 2016, the budget allocated for environmental protection of the province was 109,304 million VND, accounting for 1.13% of the total provincial budget.

Main problems and challenges related to the current waste management system:

Some of the main problems in Phu Tho related to the current waste management system are the following:

› *Collection*. There is insufficient focus on separating and minimizing waste streams, such as the organic fraction and construction waste. In addition, the vehicle fleet need to be replaced and improved

32 Decision No. 05/2017 / QD-UBND dated 10/02/2017 specifies fee for domestic waste collection and transportation in Phu Tho province. Decision No. 11/2017 / QD-UBND dated 20/4/2017 regulates the fee of environmental public services in Viet Tri city and Phu Tho town, Phu Tho province. Treatment fee of domestic waste for Phu Tho Waste Treatment Joint Stock Company is regulated by Decision No. 12/2017 / QD-UBND dated 20/4/2017.

coordination between districts is required in order to utilize the transportation capacity (optimal transportation route, combining waste to be transported in districts, etc.).

- *Transport*. A transfer station and large transfer vehicles must be established for the transfer of waste over long distance to the new incinerator.
- *Disposal*. Unsanitary landfills (dumpsites) are operated in mountainous districts. The landfills in Yen Lap, Doan Hung and Cam Khe have no technical infrastructure, disposal celling, lining, leachate collection and treatment.
- *Treatment*. Nine small incinerators (with capacities lees than 100 tons/day) have been established to treat domestic waste in some districts. However, due to poor flue gas cleaning equipment the environmental protection requirements specified in QCVN 61-MT: 2016/BTNMT National Technical Regulation on Domestic Waste Incinerators are not yet met. Thus, the incinerators are expected to generate air pollutant emissions, while renovations and upgrades to install proper flue gas cleaning equipment are difficult and costly.
- *Foreseen treatment*. Since no detailed technical appraisal has yet been carried out, it is unclear whether the new proposed incineration facility will have sufficient flue gas cleaning equipment to avoid polluting the air, enabling it to meet Vietnamese standards. In addition, it is unclear if the waste that will feed the incinerator can meet the calorific requirements for waste suitable for incineration. A large part of the organic fraction would need to be removed to enable the waste to meet the calorific values required (typically more than 9,000 KJ/kg).
- *Treatment/disposal*. There is substantial pollution at the Viet Tri Urban Waste Treatment Plant. The factory was built and put into operation in 1998, with a design capacity of 60 tons/day. The facility is currently operating overloaded (nearly 400% over design capacity). Equipment and facilities have been degraded; disposing cells are full; and there is no surface water collection and splitting system, as required. An inefficient leachate treatment system has polluted the environment at the plant and the surrounding area. The plant is likely to be closed in 2018.
- *Institutional*. The late issuing of the necessary solid waste management policies, leads to inconsistency in waste management.
- *Financing*. A targeted support mechanism funded by state budget for implementing rehabilitation projects for severe environmental polluting facilities is in place. The support from central budget has helped local authorities to deal with pollution sources from the public utilities sector and to improve the local environment to a certain extent. However, the support is not sufficient to implement proper pollution treatment, specifically for landfills. The fees are insufficient to cover the costs of the current waste management system and to support more expensive, advanced waste treatment

Assessment of four options/scenarios for swm improvements in Phu Tho

The four different options/scenarios for the modernization of Solid Waste Management for Phu Tho, are detailed below. The scenarios present the amount of waste that can be expected in the period 2018-2030, the amount of solid waste infrastructure that would be needed to deal with the waste flows in the different options/scenarios, the corresponding impacts on investment and operational costs as well as the accompanying implications for waste fee increases and the remaining financing gaps.

Option/Scenario 1 - Basic Solid Waste Management System

The basic solid waste management system includes improvement of collection and transportation, incl. use of transfer stations prior to transportation to proper landfills. Apart from sorting of recyclables during the collection and transportation process, the system does not include any further treatment and/or reduction measures. This option is analysed in order to be used for comparison with three other options. Option 1 is unlikely to be implemented in Phu Tho, as there are in fact substantial plans for the establishment of a new waste incinerator in the province. The waste flow for Option 1 within the planning period from 2018 to 2030 is presented in Table 2-36 below.

Development of the waste flow within the planning period is further illustrated in Figure 2-22 below. In this option/scenario, amounts for landfill disposal continue to grow rapidly during the planning period, due to limited recycling and no other kind of treatment.

TABLE 2-36 **Option 1/Scenario 1 – Waste flow forecast Phu Tho 2018 – 2030**

Item	Year 2018	Year 2030
Option 1: Basic Solid Waste Management System		
Collection rate – Urban (%)	97	100
Collection rate – Rural (%)	50	50
Collection Total (t/y)	346,188	858,187
Recycling (%)	10	10
Recycling (t/y)	34,619	85,819
Residual waste for landfill (%)	90	90
Residual waste for landfill (t/y)	311,569	772,368
Residual waste for landfill - Accumulated (t)		6,833,601

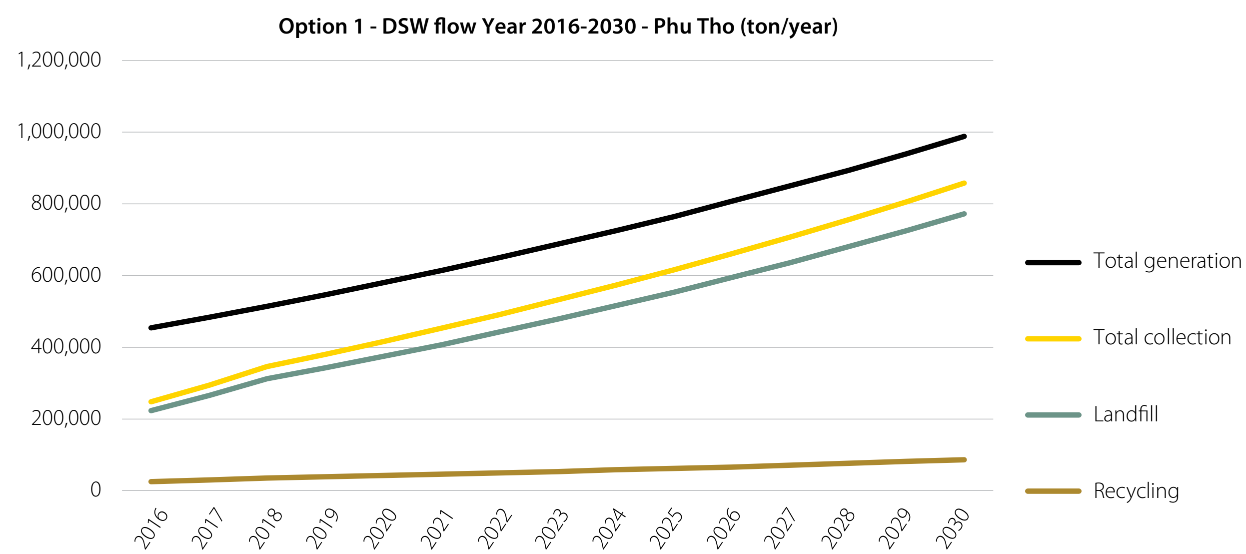


FIGURE 2-22 **Option/Scenario 1 – Basic Solid Waste Management System – waste flow for Phu Tho (ton/year)**

The necessary systems and facilities for handling of the waste in the future are listed in Table 2-37.

The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal required in each of the four-year periods until 2030 are presented in Table 2-38.

The costs demonstrate the investments associated with the upgrading of the collection equipment (pushcarts, containers), and the costs of disposal infrastructure (sanitary and environmentally compliant landfills) including transfer stations to optimize transport to the landfill. This option/scenario does not include more advanced solid waste treatment infrastructure. These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as a part of a specific feasibility study analysis. The estimated operational and maintenance costs are presented in Table 2-39 below.

TABLE 2-37 **Option 1, Phu Tho – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Comments
Option 1: Basic Solid Waste Management System			
Transfer points in streets (No.)	903	1,479	1 per 1000 persons
Pushcarts/containers (No.)	843	2,090	0.75 m^3, 1 m3, 5 loads/day.
Compaction trucks for collection (No.)	35	87	15 m^3, 7.5 t, 4 trips/d
Transfer stations (No.)	2	5	Capacity each: 200,000 t/y
New landfills (2 mln tons capacity each)	1	4	

TABLE 2-38 **Option/Scenario 1 – Basic Solid Waste Management System: Total investments estimated for Phu Tho for Solid Waste Collection and Disposal (US$)**

Option/Scenario 1	2018-2021	2022-2025	2026-2030	Total
Collection	7,023,000	3,005,000	6,149,000	16,176,000
Disposal	31,000,000	17,000,000	27,000,000	75,000,000
Total	38,023,000	20,005,000	33,149,000	91,176,000

TABLE 2-39 **Option/Scenario 1 – Annual operation and maintenance costs for Phu Tho for Solid Waste Collection and Disposal (US$)**

Option/Scenario 1	2018-2021	2022-2025	2026-2030	Total
Collection	16,580,000	22,897,000	39,113,000	78,591,000
Disposal	22,000,000	32,200,000	64,800,000	119,000,000
Total	38,580,000	55,097,000	103,913,000	197,591,000

TABLE 2-40 Option 1, Phu Tho – Total average costs per person per year

Option/Scenario 1: Basic Solid Waste Management System	US$/person/Year	US$/Ton	VND/person/Year	VND/ton
Total investments and reinvestments	3.76	10.77	85.456	208,300
Total operation and maintenance costs	9.01	25.76	204,443	523,500
Total annual costs	**12,77**	**36.53**	**289,899**	**731,800**

The operational costs of collection and disposal also gradually increase as new pushcarts, containers, trucks and transfer stations are rolled out together with the new and environmentally sanitary landfills required for the increase in waste generation in this option/scenario. Where full cost recovery is introduced and all costs are to be covered by normal residents, the average cost per person will be as shown in Table 2-40.

The average salary in Vietnam is VND 4,845,000/month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 50-75% of the average costs as presented above.

If the fees were to be increased to what is considered to be internationally affordable, this would still leave an annual financing gap of VND 71,874 – 144,549 per person per year or US$31- US$63 million per year.

Option 2 – Waste reduction, reuse and recycling

In this scenario the recycling at source is forecasted to grow to 13% and in addition waste recycling is forecasted to grow from the current 12% to 24% in 2030.

This leads to an increase in recycling materials from the current 46,691 tons per year to about 335,000 tons per year in 2030. In this scenario, much less waste needs landfilling, from 299,497 tons per year in the beginning to 523,713 ton per year in 2030. The waste flow collected, recycled and landfilled in option/scenario 2 is presented in Table 2-41 below for the planning period from 2018 to 2030.

TABLE 2-41 Option/Scenario 2 – Waste flow forecast Phu Tho for Year 2018 – 2030

Item	Year 2018	Year 2030
Option 2: Waste reduction, reuse and recycling at source		
Collection rate – Urban (%)	97	100
Collection rate – Rural (%)	50	50
Collection Total (t/y)	346,188	858,187
Sorting/recycling at source (%)	1	13
Sorting/recycling during collection (%)	12	24
Recycling in total (t/y)	46,691	334,474
Residual waste for landfill (%)	87	61
Residual waste for landfill (t/y)	299,497	523,713
Residual waste for landfill - Accumulated (t)		5,407,746

The development of the waste flow within the planning period is further illustrated in Figure 2-23 below. Although recycling has been increased, the amounts for landfill disposal continue to grow during the planning period.

The necessary systems and facilities for the future handling of the waste are listed in Table 2-42 below.

The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal required in each of the four-year periods to 2030, are presented in Table 2-43 below.

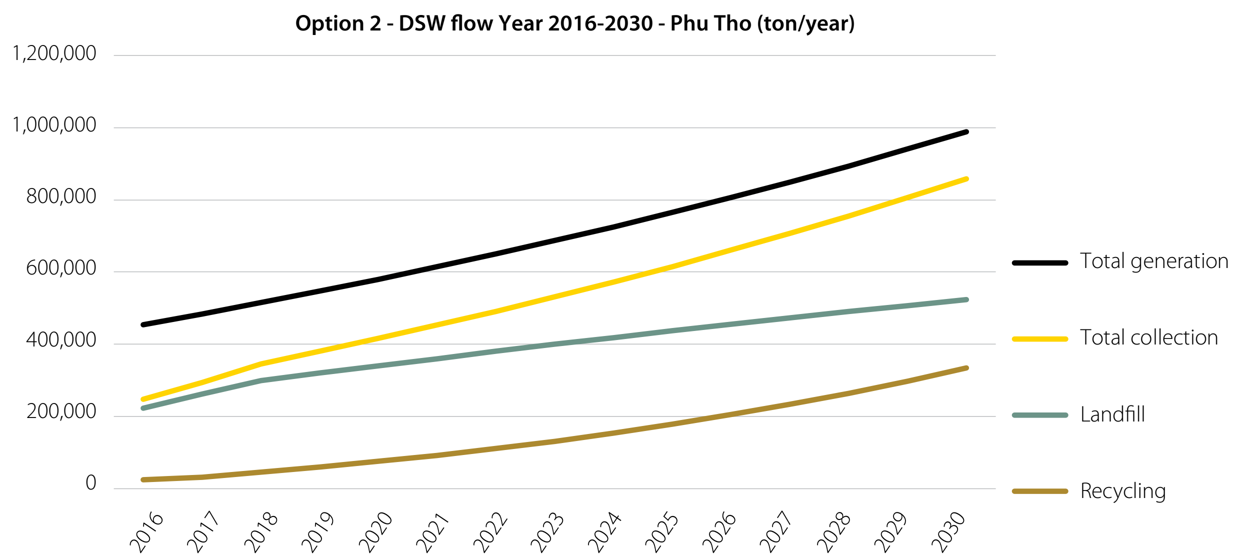


FIGURE 2-23 **Option/Scenario 2 – Waste reduction, reuse and recycling at source – Phu Tho (ton/year)**

TABLE 2-42 **Option 2, Phu Tho – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Comments
Option 2: Waste reduction, reuse and recycling at source			
Transfer points in streets (No.)	903	1,479	1 per 1000 persons
Pushcarts (No.)	843	2090	0.75 m^3, 1 m3, 5 loads/day.
Compaction trucks for collection (No.)	35	87	15 m^3, 7.5 t; 4 trips/d
Transfer stations (No.)	2	5	Capacity each: 200,000 t/y
New landfills (2 mln tons capacity each)	1	3	

TABLE 2-43 **Option/Scenario 2 – Waste Reduction Reduce, Recycling: Total investments estimated for Phu Tho for Solid Waste Collection and Disposal (US$)**

Option/Scenario 2	2018-2021	2022-2025	2026-2030	Total
Collection	7,023,000	3,005,000	6,149,000	16,176,000
Disposal	31,000,000	17,000,000	17,000,000	65,000,000
Total	38,023,000	20,005,000	23,149,000	81,176,000

The costs for collection are comparable to those under the first option/scenario, while the costs for disposal[33] are substantially lower. The reduced costs for disposal are largely due to the reduced landfill capacity required in this scenario. Separation of waste by households is difficult to achieve and only limited success has been achieved in many countries, despite decades of effort and outreach. Separation of waste, especially paper and plastic from commercial and institutional establishments and organic waste from kitchens, restaurants, markets and hotels can be more attractive, in view of the larger quantities for recycling. The estimated operational and maintenance costs are presented in Table 2-44 below, but do not include the Vietnam specific costs for outreach, public awareness and education required to make recycling at source a potential success.

The operational costs for collection and disposal, gradually increase as new pushcarts, containers, trucks and transfer stations are rolled out together with the new and environmentally sanitary landfills that are required for the continued increase in waste generation in this option/scenario. Where full cost recovery is introduced and all costs are to be covered by normal residents, the average costs per person will be as shown in Table 2-45 below.

The average salary in Vietnam is VND 4,485,000 per month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 53-80% of the average costs as presented above.

If the fees were to be increased to what is considered to be internationally affordable, this would still leave an annual financing gap of VND 55,355 – 128,030 per person per year or US$24- US$56 million per year.

TABLE 2-44 **Option/Scenario 2 – Annual operation and maintenance costs for Phu Tho Solid Waste Collection and Disposal (US$)**

Option/Scenario 2	2018-2021	2022-2025	2026-2030	Total
Collection	16,580,000	22,897,000	39,113,000	78,591,000
Disposal	22,000,000	32,200,000	56,800,000	111,000,000
Total	38,580,000	55,097,000	95,913,000	189,591,000

TABLE 2-45 **Option 2, Phu Tho – Total average costs per person per year**

Option/Scenario 2: Basic Solid Waste Management System and recycling	US$/person/Year	US$/Ton	VND/person/Year	VND/ton
Total investments and reinvestments	3.35	9.59	76,074	217,601
Total operation and maintenance costs	8.69	24.86	197,306	564,374
Total annual costs	**12.04**	**34.45**	**273,380**	**781,975**

33 These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis.

Option 3 – Low cost waste treatment

In this scenario, Mechanical Biological Treatment facilities are employed to mechanically separate the household waste, in order to separate the organic fraction for composing and a Refuse Derived Fuel fraction that is suitable for co-processing at cement plants (or waste-to-energy plants).

In this scenario, there is an increase in recycling materials from 34,619 tons per year to about 171,637 tons per year in 2030; 171,637 tons of compost would be produced in 2030 as well as 255,740 tons per year of Refuse Derived Fuel that can be used in the cement industry. In this scenario, much less waste needs landfilling, from 152,323 tons per year in the beginning to 255,740 ton per year in 2030. The waste flow collected, recycled and landfilled in option/ scenario 3 is presented in the Table 2-46 below for the planning period from 2018 to 2030.

The development of the waste flow within the planning period is further illustrated in Figure 2-24 below. Amounts for landfilling are limited due to the significant positive impact of composting and the use of RDF in cement plants.

TABLE 2-46 Option 3 – Waste flow forecast Phu Tho 2018 – 2030

Item	Year 2018	Year 2030
Option 3: Low cost waste treatment		
Collection rate – Urban (%)	97	100
Collection rate – Rural (%)	50	50
Collection Total (t/y)	346,188	858,187
Recycling (%)	10	20
Recycling (t/y)	34,619	171,637
Compost (%)	2	20
Compost (t/y)	6,924	171,637
Other treatment, RDF for cement industry (%)	44	30
Other treatment, RDF for cement industry (t/y)	152,323	255,740
Residual waste for landfill (%)	44	30
Residual waste for landfill (t/y)	152,323	255,740
Residual waste for landfill - Accumulated (t)		2,712,607

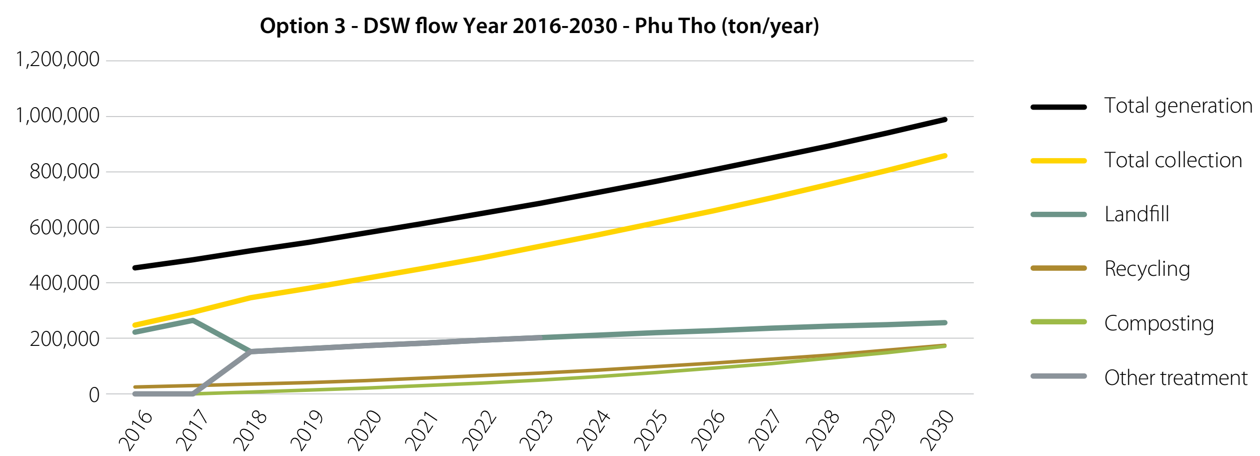


FIGURE 2-24 Option/Scenario 3 – Low cost waste treatment – Phu Tho (ton/year)

The necessary systems and facilities for the future handling of the waste are listed in Table 2-47 below.

The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11. In this scenario, the transfer stations are integrated with the MBT facilities. The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal needed in each of the four-year periods to 2030 are presented in Table 2-48 below.

The costs for collection are comparable to those under the first option/scenario, while the costs for disposal/treatment[34] are substantially higher due to the mechanical biological treatment systems. The advantage is that there is substantially less need for landfilling and landfills. The estimated operational and maintenance costs are presented in Table 2-49 below.

The mechanical biological treatment stations that would be rolled out under this scenario are also the main costs driver for operational costs, as there would be a requirement for one new, environmentally sanitary landfill only. Where full cost recovery is introduced and all costs are

TABLE 2-47 **Option 3, Phu Tho – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Comments
Option 3: Low cost waste treatment			
Transfer points in streets (No.)	903	1,479	1 per 1000 persons
Pushcarts/containers (No.)	843	2090	0.75 m³, 1 m3, 5 loads/day.
Compaction trucks for collection (No.)	35	87	15 m³, 7.5 t; 4 trips/d
Transfer stations (No.)	0	0	Capacity each: 200,000 t/y
MBT facilities	2	5	Capacity each: 200,000 t/y
Other treatment, RDF for cement industry (No.)	0	0	Existing cement factories
New landfills (2 mln tons capacity each)	1	2	

TABLE 2-48 **Option/Scenario 3 – Low cost waste treatment: Total investments estimated for Phu Tho for Solid Waste Collection and Disposal (US$)**

Option/Scenario 3	2018-2021	2022-2025	2026-2030	Total
Collection	7,023,000	3,005,000	6,149,000	16,176,000
Disposal	145,000,000	45,000,000	55,000,000	245,000,000
Total	152,023,000	48,005,000	61,149,000	261,176,000

TABLE 2-49 **Option/Scenario 3 – Annual operation and maintenance costs Phu Tho for Solid Waste Collection and Disposal (US$)**

Option/Scenario 3	2018-2021	2022-2025	2026-2030	Total
Collection	16,580,000	22,897,000	39,113,000	78,591,000
Disposal/treatment	68,000,000	86,000,000	154,000,000	308,000,000
Total	84,580,000	108,897,000	193,113,000	386,591,000

34 These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis.

to be covered by normal residents, the average costs per person would be as shown in Table 2-50 below.

The average salary in Vietnam is VND 4,845,000/ month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 24-36% of the average costs as presented above.

If the fees were to be increased to what is considered to be internationally affordable, this would still leave an annual financing gap of VND 390,315 – 462,990 per person per year or US$170- US$201 mln per year.

Option 4 – Advanced treatment technologies

In this scenario, similar to option 3, Mechanical Biological Treatment facilities are employed to mechanically separate the household waste, in order to separate the organic fraction for composing and a Refuse Derived Fuel fraction that is then incinerated in dedicated Waste-to-Energy plants.

As in the third option/scenario, this leads to an increase in recycling materials from the 34,619 tons per year to about 171,637 tons per year in 2030; an amount of 171,637 tons of compost is produced in 2030 and 365,000 tons per year of waste is incinerated. In this scenario, much less waste needs landfilling, from 304,646 tons per year in the beginning to 200,800 ton per year in 2030. The waste flow collected, recycled and landfilled in option/scenario 3 is presented in Table 2-15 below for the planning period from 2018 to 2030.

TABLE 2-50 **Option 3, Phu Tho – Total average costs per person per year**

Option/Scenario 3: Low Costs Treatment	US$/person/Year	US$/Ton	VND/person/Year	VND/ton
Total investments and reinvestments	8.99	25.71	204,068	583,715
Total operation and maintenance costs	17.81	50.94	404,272	1,156,378
Total annual costs	**26.80**	**76.66**	**608,340**	**1,740,093**

TABLE 2-51 **Option 4 – Waste flow Forecast Phu Tho 2018 – 2030**

Item	Year 2018	Year 2030
Option 4: Advanced treatment technologies		
Collection rate – Urban (%)	97	100
Collection rate – Rural (%)	50	50
Collection Total (t/y)	346,188	858,187
Recycling (%)	10	20
Recycling (t/y)	34,619	171,637
Compost (%)	2	20
Compost (t/y)	6,924	171,637
Waste-to-Energy (%)	0	43
Waste-to-Energy (t/y)	0	365,000
Residual waste for landfill (%)	88	23
Residual waste for landfill (t/y)	304,646	200,800
Residual waste for landfill - Accumulated (t)		2,631,071

The development of the waste flow within the planning period is further illustrated in Figure 2-25 below. Amounts for landfilling are limited due to the significant positive impact from composting and the incineration of RDF in Waste-to-Energy plants.

The necessary systems and facilities for handling of the waste in future are listed in Table 2-52.

The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11. In this scenario, the transfer stations are integrated with the MBT facilities. The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal required in each of the four-year periods to 2030 are presented in Table 2-53.

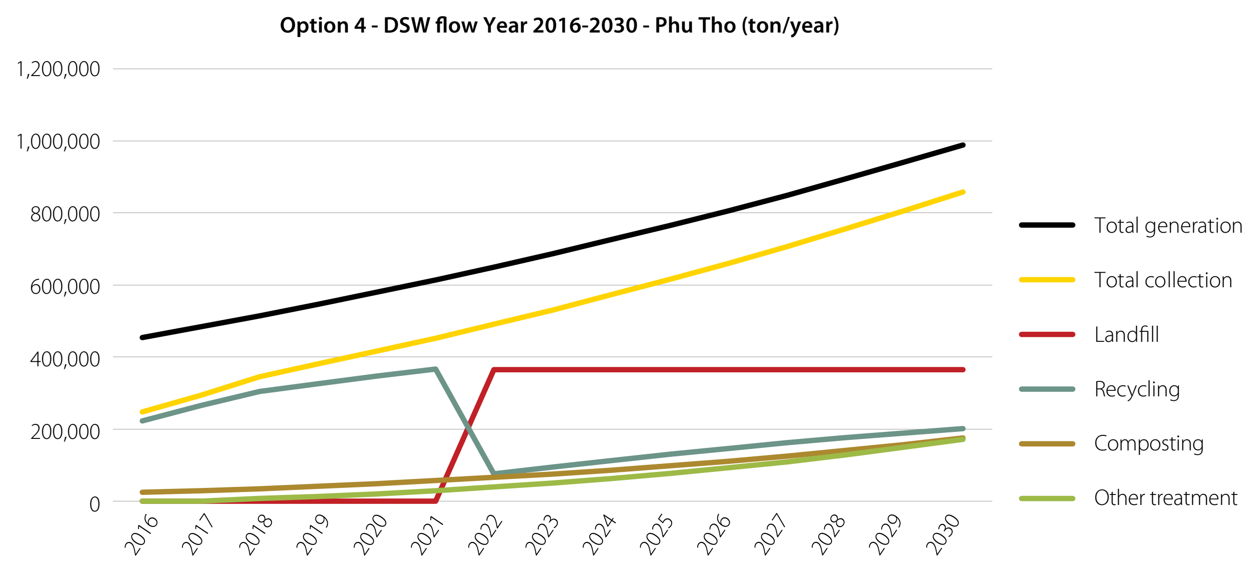


FIGURE 2-25 **Option/Scenario 4 – Advanced treatment technologies – Phu Tho (ton/year)**

TABLE 2-52 **Option/Scenario 4, Phu Tho – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Comments
Option 4: Advanced treatment technologies			
Transfer points in streets (No.)	903	1,479	1 per 1000 persons
Pushcarts/containers (No.)	843	2,090	0.75 m³, 1 m3, 5 loads/day.
Compaction trucks for collection (No.)	35	87	15 m³, 7.5 t; 4 trips/d
Transfer stations (No.)	0	0	Capacity each: 200,000 t/y
MBT facilities	2	5	Capacity each: 200,000 t/y
Waste-to-energy plants (No.)	0	1	Capacity each: 1,000 t/day
New landfills (2 mln tons capacity each)	1	2	

TABLE 2-53 **Option/Scenario 4 – Advanced waste treatment: Total investments estimated for Phu Tho for Solid Waste Collection and Disposal (US$)**

Option/Scenario 4	2018-2021	2022-2025	2026-2030	Total
Collection	7,023,000	3,005,000	6,149,000	16,176,000
Disposal	145,000,000	195,000,000	55,000,000	395,000,000
Total	152,023,000	198,005,000	61,149,000	411,176,000

The costs for collection are comparable to those under the first option/scenario, while the costs for disposal/treatment[35] are substantially higher due to the waste to energy plants. When compared to option 3, an advantage of this scenario is that there is substantially less need for landfilling and landfills, the disadvantage is that RDF is not provided to the cement plants in this scenario. The estimated operational and maintenance costs are presented in Table 2-54 below.

The mechanical biological treatment stations and waste to energy plants are the main costs driver for operational costs under this option, as there is only one new, environmentally sanitary landfill needed. Where full cost recovery is introduced and all costs are to be covered by normal residents, the average costs per person would be as shown in Table 2-55 below.

The average salary in Vietnam is VND 4,845,000/month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 19-28% of the average costs as presented above.

If the fees were to be increased to what is considered to be internationally affordable,

TABLE 2-54 **Option/Scenario 4 – Annual operation and maintenance costs Phu Tho for Solid Waste Collection and Disposal (US$)**

Option/Scenario 4	2018-2021	2022-2025	2026-2030	Total
Collection	16,580,000	22,897,000	39,113,000	78,591,000
Disposal/treatment	68,000,000	118,000,000	190,000,000	376,000,000
Total	84,580,000	140,897,000	229,113,000	454,591,000

TABLE 2-55 **Option/Scenario 4, Phu Tho – Total average costs per person per year**

Option/Scenario 4: Advanced Treatment Technologies	US$/person/year	US$/ton	VND/person/year	VND/ton
Total investments and reinvestments	13.52	38.68	306,973	878,065
Total operation and maintenance costs	20.79	59.47	471,968	1,350,014
Total annual costs	**34.31**	**98.15**	**778,941**	**2,228,078**

35 These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis.

this would still leave an annual financing gap of VND 560,916 – 633,591 per person per year or US$244- US$275 million per year.

Planning for future waste management improvements and related investments should be based on the availability of reliable information on waste quantities, composition, generation rates, and waste density in both urban and rural areas. Investment decisions need to be based on more detailed feasibility analysis, including more data collection and data verification. A key recommendation for provinces and cities that are planning infrastructure investments with or without the private sector is: to **budget the funds required for a detailed feasibility analysis of solid waste management technologies, skills development, capacity building and monitoring/enforcement and to prepare the roadmap/masterplan at the regional level that can form the basis for selecting specific investments and technologies.**

The necessary institutional and operational capacity building needs to precede even basic infrastructure upgrading, including improvements in revenue collection. Considering the current low capacities, substantial training and capacity building programs will be needed in the areas of: (i) policy formulation and planning; (ii) legislation; (iii) infrastructure feasibility analysis and design; (iv) budgeting and accounting; (v) technical operation; and (vi) monitoring and enforcement. Sustainable private sector participation is viable when supported by appropriate legislation, regulations, monitoring, enforcement, increa-sed waste fees and government capacity. The legal framework will also need to establish a transparent financing mechanism with cost-recovery targets from user fees and institute a system to enforce payments.

2.3.3 HAI PHONG

This section includes an analysis of the existing solid waste management situation in Hai Phong as well as presenting the four different waste strategy options/scenarios. The options include analysis of the waste flows, costs and affordability which can be used by authorities for (financial) planning of solid waste management improvements.

Current waste management in Hai Phong

Hai Phong is a coastal city located 102 kilometres to the Northeast of Hanoi. The province borders with Quang Ninh province to the North, Hai Duong province to the West, Thai Binh province to the South, and Bac Bo Bay in the East Sea.

The city has a significant position in the socio-economic development, national defence and security of the North and the whole country. Hai Phong is a sea transport hub in the North which benefits from: a deep seaport; a development motivation of the Northern key economic region, a general economic, science and technology centre of the Northern delta area; and one of the two development centres of the Northern key economic region. Hai Phong possesses various large-scale industrial zones, as well as trade, service, tourism, education, medical and aquaculture centres of the Northern delta area.

Hai Phong is the third largest city of Vietnam after Ho Chi Minh City and Hanoi and is one of the five cities under the direct control of the Central Government. The city is the first-ranked central city at the national level. Hai Phong's urban system consists of 7 central urban districts and 11 district towns and townships. The total area of the province is 156,176 ha.

Hai Phong is one of the most rapidly urbanizing cities in Vietnam. By 2015, the city's urbanization rate was 46.73%, 1.40 times higher than the national urbanization rate average (33.40%) and ranking third among the provinces in the Northern key economic region. The Hai Phong urbanization rate is nearly equal to that of Hanoi (47.55%). There are 1,980,800 inhabitants in Hai Phong city, with an annual growth rate of 0.89%. There are 925,900 inhabitants in the urban districts and 1,054,900 inhabitants in the rural districts. For the period from 2018 to 2030 urban population is expected to continue to grow and the rural population will continue to decrease as shown in Table 2-56 below.

Waste collection, transport and disposal/ treatment

According to DOC, the average domestic waste generation rates in the urban and rural areas are 1.25 kg/cap/day and 0.82 kg/cap/day, respectively. Collection rates were reported to be 97% in urban areas and 81% in rural areas; the collection rates reported for rural areas seem to be too high because most of the rural waste is still scattered around and no plans exist yet for collection and treatment/disposal of this waste, with the exception of some communes (An Duong district - Hai Phong City).

In the urban areas people put their household waste along the roads and central areas. The waste is collected daily by collection workers using pushcarts. They transfer waste to collection points where it is emptied into compaction trucks for further transportation to the landfills (and minor amounts to the compost plant). Urban waste collection and transport is assigned to 3 companies including Hai Phong URENCO Ltd, Hai Phong Public Works & Construction Co. Ltd., and Hai Phong Public and Tourism Service JSC. In rural areas, waste collection is to some extent organised by district authorities, who mainly dump the waste at uncontrolled dumpsites. DSW is collected and transported by means of compaction trucks, open trucks, and pushcarts. However, some districts still use small trucks, farm vehicles or other rudimentary vehicles due to lack of proper equipment. The equipment currently used by Hai Phong URENCO includes:

Equipment for collection and transportation: (i) 65 compaction trucks (4 m^3: 6 trucks, of which 01 is not operating; 6 m^3: 10 trucks, of which 09 are not operating; 8 m^3: 28 trucks, of which 04 are not operating; 10 m^3: 9 trucks, of which 02 are not operating; 11 m^3: 2 trucks, of which 02 are not operating; 12 m^3: 5 trucks; 14.5 m^3: 5 trucks); (ii) 1,056 pushcarts including 1,036 pushcarts of 500L and 20 pushcarts of 660L;

TABLE 2-56 **Forecast of population and waste generation for Hai Phong**

Item	Year 2016	Year 2018	Year 2030	Comments
Urban population (No.)	925,900	943,202	1,054,018	Increasing (0.89%/year)
Rural population (No.)	1,054,900	1,073,122	1,189,260	Increasing (0.89%/year)
Total population (No.)	1,980,800	2,016,324	2,243,278	Annual growth: 0.89%
Urban DSW generation (t/y)	422,442	450,288	660,441	Increasing
Rural DSW Generation (t/y)	315,732	336,077	488,840	Decreasing
Total DSW generation (t/y)	738,173	786,366	1,149,281	Annual growth: 3.21%
Urban DSW gen. (kg/cap./day)	1.25	1.31	1.72	
Rural DSW gen. (kg/cap./day)	0.82	0.86	1.13	
Total DSW gen. (kg/cap./day)	1.02	1.07	1.40	

(iii) 06 waste containers: 60L & 240L; (iv) others: 04 water spraying trucks of 7m^3, 03 refrigerated trucks, 02 sweeping trucks, 02 septic tank trucks, 01 self-propelled crane, and 03 loader trucks. Recyclable materials, such as plastic, nylon, papers are sorted and handled by the informal sector.

Equipment for waste treatment at the landfill includes 02 excavators; 07 bull dozers; and 04-wheel loaders.

URENCO Hai Phong has an existing composting plant with a capacity of 50 ton/day based on Korean technology, which has been producing compost based on mixed DSW. However, as the input was unsorted waste, the compost produced was of poor quality and could not be sold.

Nearly all waste collected goes directly for landfill disposal. The existing landfills are being operated – Dinh Vu, Bang Lal and Trang Cat Landfills. The disposal capacity is almost exhausted at Dinh Vu and Trang Cat landfills. The major waste treatment and disposal facilities for urban areas are Trang Cat Waste Treatment Complex; Dinh Vu landfill and Gia Minh Waste Treatment Complex:

- Trang Cat Waste Treatment Complex, consists of the following key facilities: (i) Composting plant with capacity of 50 tons/day using Japanese technology; input is organic waste from markets, waste from urban tree trimmings, hotels and restaurants, used to produce a higher quality compost. The main processes are: sorting – aerobic composting – final composting. The plant is still being operated as a pilot plant, with the composting process being tested and further sources of separated organic wastes being investigated. Organic fertilizer (compost) products are of high quality (the compost samples were analysed at the National Fertilizer Testing Centre, Ministry of Natural Resources and Environment). The compost has been used in experimental gardens at the Trang Cat Waste treatment complex and at the strip of green parks in the city centre.; (ii) Trang Cat landfill (11.3 ha – 1,700,000 m^3) 587 tons/day. Although the landfill is still being used, it has reached its capacity and is full; and (iii) medical waste incinerator with design capacity of 200 kg/h. The plant runs with capacity of 1000-1200 kg/day due to an insufficient amount of medical waste. The incinerator operates for 7-8 hours/day.
- Dinh Vu Landfill (29.6 ha), with a total capacity of 547.98 tons/day consisting of the following key facilities: (i) semi aerobic pilot landfill (5,000 m^3 – Japanese Fukuoka technology); and (ii) sanitary landfill (9.6 ha – 1,500,000 m^2), which is also full. The remaining landfill area is 5.95 ha, will be used to receive the waste from Thuong Ly landfill. At the current stage, about 13.95 ha of this land area has not yet been cleared.
- Bang La Landfill (2.0 ha), receives the domestic solid waste from Do Son and Kinh Duong and has a total capacity of 136.5 tons/day.
- Gia Minh Waste Treatment Complex (35 ha) uses Fukuoka technology with the objective to reduce the load for Trang Cat and Dinh Vu Solid waste treatment Complexes and to collect and dispose of all the solid waste from the North of the city.

For the rural areas, there are five landfills/dumpsites: One at Tien Lang; two at Thuy Nguyen; two at Cat Hai) and 114 temporary dumpsites at communes.

FIGURE 2-26 **Example of overloaded landfill in Hai Phong**

Financial

Table 2-57 below details the current user fees for waste and how they are collected. The Hai Phong URENCO is assigned to collect the sanitation fee in the urban districts and a part of the rural districts.

TABLE 2-57 **Fees for domestic waste collection and transportation in Hai Phong City**[36]

No.	Customer category	Unit	Fees (incl. VAT)
I	**Households with no production or business**		
1	Households (road, street, alley, apartment building)	VND/households/month	40,000
2	Individual households, Motel		20,000
II	**Households with small business**		
1	Catering	VND/households/month	135,000
2	repairing, building materials, foods, electric, apparel business	VND/households/month	135,000
3	Grocery, car wash and others	VND/households/month	90,000
III	**Administrative units, Armed Forces, schools, kindergartens, offices, Branch representatives; shops, hotels, restaurants, other services; production & business units (factories, companies, railway stations, bus stations, markets ...), hospitals and private clinics**		
1	With monthly waste volume by domestic, business & services (excluding construction, hazardous and medical wastes) ≤ 1 m^3/month	VND/unit/month	324,000
2	With monthly waste volume by domestic, business & services (excluding construction, hazardous and medical wastes) ≤ 1 m^3/month	VND/m^3	324,000

36 Decision No. 3275/2016 /QD-UBND dated 22/12/2016 on the fee for collection, transportation and treatment of domestic waste at the city urban area

In addition, there is funding from the City People Committee (CPC) for environmental protection, which in 2015 accounted for 4.35% of the budget for regular expenditures.

Main problems related to the current waste management system:

The main solid waste management problems that affect Hanoi and Phu Tho are also issues in Hai Phong:

- *Collection*. There is insufficient focus on separating and minimizing waste streams, such as the organic fraction and construction waste. While the city has started to collect separate organic waste streams from markets, hotels, and restaurant, the amount of organic waste collected is insufficient for the operational capacity of the plant. Therefore, separation at source for organic waste needs to be expanded to cover the entire the city.
- *Disposal*. Unsanitary landfills (dumpsites) are still being operated. The landfills at the Trang Cat Waste Treatment Complex and Dinh Vu Landfill lack sufficient technical infrastructure, disposal celling, lining, leachate collection and treatment and are full to capacity.
- *Treatment/disposal*. The composting plant can substantially reduce landfill volumes if rigorous separate collection can be expanded together with quality control and testing.
- *Institutional*. Late issuing of the necessary solid waste management policies leads to inconsistencies in waste management.
- *Financing*. The financial support from the central budget is insufficient to implement proper pollution treatment, especially for landfills. The fees are insufficient to cover the costs of the current waste management system and more expensive advanced waste treatment. In addition, only part of the fees is collected.

Assessment of four options/scenarios for swm improvements in Hai Phong

The four different options/scenarios for modernization of Solid Waste Management in Hai Phong are detailed below. The options include the amount of waste that can be expected in the period 2018-2030, the amount of solid waste infrastructure that would be needed to deal with the waste flows in the different options/scenarios as well as the corresponding impacts on investment and operational costs and the accompanying implications for waste fee increases and the remaining financing gaps.

Option 1 - Basic Solid Waste Management System:

A basic solid waste management system is presented and analysed below. The system includes improvement of collection and transportation, incl. the use of transfer stations prior to transportation to proper landfills. Apart from sorting of recyclables during the collection and transportation process, the system does not include any further treatment and/or reduction measures. The Waste flow for Option 1 within a planning period from 2018 to 2030 is presented in Table 2-58.

TABLE 2-58 **Option/Scenario 1 – Waste flow forecast Hai Phong 2018 – 2030**

Item	Year 2018	Year 2030
Option 1: Basic Solid Waste Management System		
Collection rate – Urban (%)	97	100
Collection rate – Rural (%)	60-81	81
Collection Total (t/y)	710,932	1,056,402
Recycling (%)	10	10
Recycling (t/y)	71,093	105,640
Residual waste for landfill (%)	90	90
Residual waste for landfill (t/y)	639,839	950,762
Residual waste for landfill - Accumulated (t)		10,217,052

The development of the waste flow within the planning period is further illustrated in Figure 2-27 below. The collection rate is gradually increased to 100% over the planning period. Due to limited recycling and the absence of other treatment options, the amounts of waste disposed of by landfilling, continues to grow rapidly during the planning period.

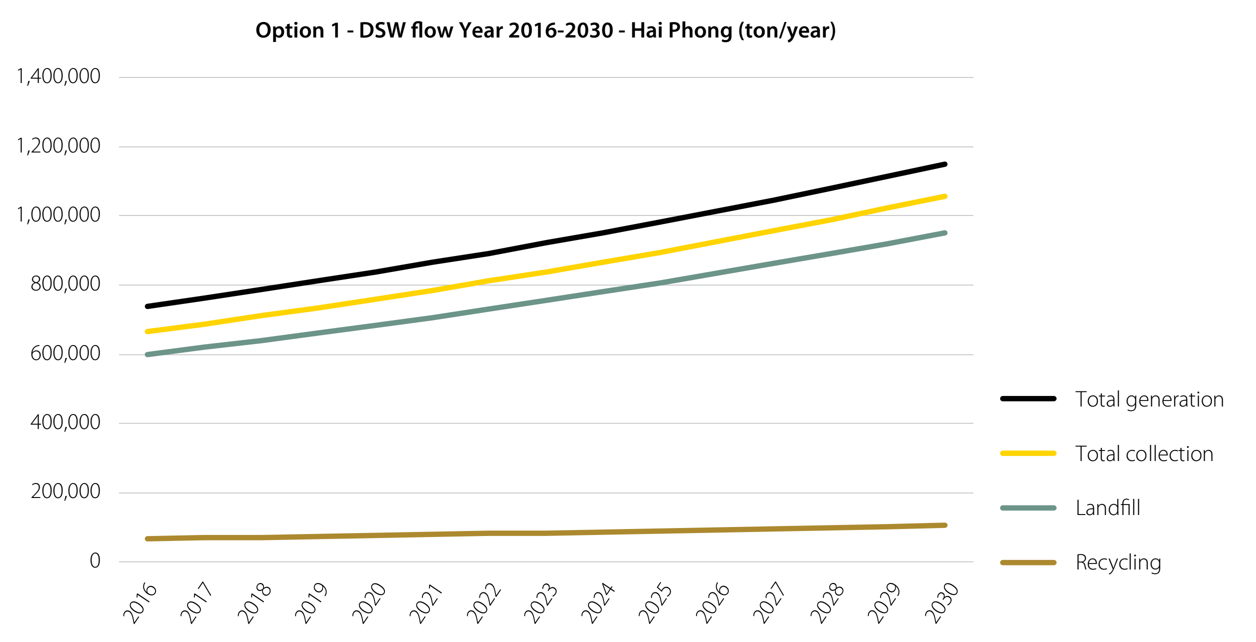


FIGURE 2-27 **Option/Scenario 1 – Basic Solid Waste Management System – Hai Phong (ton/year)**

The necessary systems and facilities for future handling of the waste are listed in Table 2-59.

The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11. The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal required in each of the four-year periods to 2030 are presented Table 2-60.

The costs demonstrate the investments associated with the upgrading of the collection equipment (pushcarts, containers), and the costs of disposal infrastructure (sanitary and environmentally compliant landfills) including transfer stations to optimize transport to the landfill. This option/scenario does not include more advanced solid waste treatment infrastructure. These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis. The estimated operational and maintenance costs are presented Table 2-61.

TABLE 2-59 **Option/Scenario 1, Hai Phong – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Comments
Option 1: Basic Solid Waste Management System			
Transfer points in streets (No.)	1,788	2,017	1 per 1000 persons
Pushcarts/containers (No.)	1,731	2,573	0.75 m^3, 1m^3, 5 loads/day
Compaction trucks for collection (No.)	72	107	15 m^3, 7.5 t; 4 trips/d
Transfer stations (No.)	4	6	Capacity each: 200,000 t/y
New landfills (2 mln tons capacity each)	1	6	

TABLE 2-60 **Option/Scenario 1 – Basic Solid Waste Management System: Total investments estimated for Hai Phong for Solid Waste Collection and Disposal (US$)**

Option/Scenario 1	2018-2021	2022-2025	2026-2030	Total
Collection	10,318,000	1,751,000	3,707,000	15,776,000
Disposal	48,000,000	17,000,000	37,000,000	102,000,000
Total	58,318,000	18,751,000	40,707,000	117,776,000

TABLE 2-61 **Option/Scenario 1 – Annual operation and maintenance costs Hai Phong for Solid Waste Collection and Disposal (US$)**

Option/Scenario 1	2018-2021	2022-2025	2026-2030	Total
Collection	31,067,000	35,379,000	51,217,000	117,664,000
Disposal	32,400,000	50,000,000	85,800,000	168,200,000
Total	63,467,000	85,379,000	137,017,000	285,864,000

TABLE 2-62 **Option 1, Hai Phong – Total average costs per person per year**

Option/Scenario 1: Basic Solid Waste Management System	US$/person/year	US$/ton	VND/person/year	VND/ton
Total investments and reinvestments	4.02	9.97	91,344	226,276
Total operation and maintenance costs	9.97	24.69	226,208	560,361
Total annual costs	**13.99**	**34.65**	**317,552**	**786,637**

The operational costs of collection and disposal gradually increase as new pushcarts, containers, trucks and transfer stations are rolled out and due to the new and environmentally sanitary landfills required for the increase in waste generation in this option/scenario. Where full cost recovery is introduced and all costs are to be covered by normal residents, the average costs per person would be as shown in Table 2-62.

The average salary in Vietnam is VND 4,845,000/month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 46-69% of the average costs as presented above.

If the fees were to be increased to what is considered to be internationally affordable, this would still leave an annual financing gap of VND 99,527 – 172,202 per person per year or US$43- US$75 million per year.

Option 2 – Waste reduction, reuse and recycling at source

In this scenario, recycling at source is forecasted to grow to 13% and in addition waste recycling is forecasted to grow from 12% currently to 24% in 2030.

This forecasted growth would lead to an increase in recycling materials from the current 93,176 tons per year to about 402,943 tons per year in 2030. In this scenario, much less waste needs landfilling, from 617,757 tons per year in the beginning to 653,459 tons per year in 2030. The waste flow collected, recycled and landfilled in option/scenario 2 is presented Table 2-63 below for the planning period from 2018 to 2030.

TABLE 2-63 **Option/Scenario 2 – Waste flow forecast Hai Phong for year 2018 – 2030**

Item	Year 2018	Year 2030
Option 2: Waste reduction, reuse and recycling at source		
Collection rate – Urban (%)	97	100
Collection rate – Rural (%)	60-81	81
Collection Total (t/y)	710,932	1,056,402
Sorting/recycling at source (%)	1	13
Sorting/recycling during collection (%)	12	24
Recycling in total (t/y)	93,176	402,943
Residual waste for landfill (%)	87	63
Residual waste for landfill (t/y)	617,757	653,459
Residual waste for landfill - Accumulated (t)		8,330,467

The development of the waste flow within the planning period is further illustrated in Figure 2-28 below. The collection rate is gradually increased to 100%. Due to limited recycling and the lack of alternative treatments, amounts for landfill disposal continue to grow during the planning period.

The necessary systems and facilities for future handling of the waste are listed in Table 2-64 below.

The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal required in each of the four-year periods to 2030 are presented in Table 2-65.

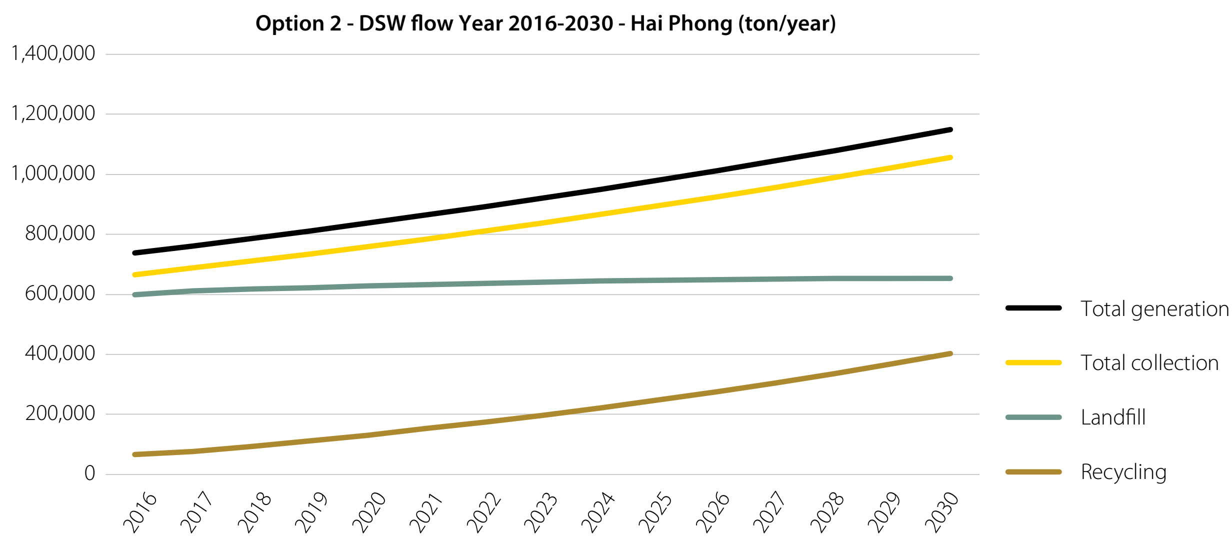


FIGURE 2-28 **Option/Scenario 2 – Waste reduction, reuse and recycling at source – Hai Phong (ton/year)**

TABLE 2-64 **Option/Scenario 2, Hai Phong – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Comments
Option/scenario 2: Waste reduction, reuse and recycling at source			
Transfer points in streets (No.)	1,788	2,017	1 per 1000 persons
Pushcarts/containers (No.)	1,731	2,573	0.75 m^3, 1 m3, 5 loads/day.
Compaction trucks for collection (No.)	72	107	15 m^3, 7.5 t; 4 trips/d
Transfer stations (No.)	4	6	Capacity each: 200,000 t/y
New landfills (2 mln. tons capacity each)	1	5	

TABLE 2-65 **Option/Scenario 2 – Waste Reduction Reduce, Recycling: Total investments estimated for Hai Phong for Solid Waste Collection and Disposal (US$)**

Option/Scenario 2	2018-2021	2022-2025	2026-2030	Total
Collection	10,318,000	1,751,000	3,707,000	15,776,000
Disposal	48,000,000	17,000,000	27,000,000	92,000,000
Total	58,318,000	18,751,000	30,707,000	107,776,000

The costs for collection are comparable to those under the first option/scenario, while the costs for disposal[37] are lower, since less landfill capacity is required. However, separation of waste by households is difficult to achieve and only limited success has been achieved in many countries despite decades of effort and outreach. Separation of waste, especially paper and plastic from commercial and institutional establishments and organic waste from kitchens, restaurants, markets and hotels is more attractive in view of the larger quantities available for recycling. The current separate collection of market waste by the city can be expanded. The estimated operational and maintenance costs are presented Table 2-66 below. These costs do not include the Vietnam specific costs for outreach, public awareness and education which are required to make recycling at source a potential success.

The operational costs for collection and disposal gradually increase over the planning period as new pushcarts, containers, trucks and transfer stations are rolled out together with the new and environmentally sanitary landfills that are required for the continued increase in waste generation in this option/scenario. Where full cost recovery is introduced and all costs are to be covered by normal residents, the average costs per person will be as shown in Table 2-67.

The average salary in Vietnam is VND 4,845,000 per month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 48-72% of the average costs as presented above.

If the fees were to be increased to what is considered to be internationally affordable, this would still leave an annual financing gap of VND 85,092 – 157,767 per person per year or US$37- US$69 million per year.

TABLE 2-66 **Option/Scenario 2 – Annual operation and maintenance costs Hai Phong for Solid Waste Collection and Disposal (US$)**

Option/Scenario 2	2018-2021	2022-2025	2026-2030	Total
Collection	31,067,000	35,379,000	51,217,000	117,664,000
Disposal	32,400,000	48,000,000	77,800,000	158,200,000
Total	63,467,000	83,379,000	129,017,000	275,864,000

TABLE 2-67 **Option/Scenario 2, Hai Phong – Total average costs per person per year**

Option/Scenario 2: Basic Solid Waste Management System and recycling	US$/person/year	US$/ton	VND/person/year	VND/ton
Total investments and reinvestments	3.70	9.16	83,907	207,854
Total operation and maintenance costs	9.65	23.92	219,210	543,025
Total annual costs	**13.35**	**33.08**	**303,117**	**750,879**

37 These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis.

Option 3 – Low cost waste treatment

In this scenario, Mechanical Biological Treatment facilities are employed to mechanically separate the household waste, in order to separate the organic fraction for composing and a Refuse Derived Fuel fraction that is suitable for co-processing at cement plants (or waste-to-energy plants).

Option 3 leads to an increase in recycling materials from the 71,093 tons per year to about 216,034 tons per year in 2030; an amount of 211,280 tons of compost would be produced in 2030 as well as 314,544 tons per year of Refuse Derived Fuel that can be used in the cement industry. In this scenario, much less waste needs landfilling, from 312,810 tons per year in the beginning to 314,544 tons per year in 2030. The waste flow collected, recycled and landfilled in option/scenario 3 is presented in Table 2-68 below for the planning period from 2018 to 2030.

The development of the waste flow within the planning period is further illustrated in Figure 2-29 below. Amounts for landfilling are limited due to the significant positive impact from composting and the use of RDF in cement plants.

TABLE 2-68 **Option 3 – Waste flow forecast Hai Phong 2018 – 2030**

Item	Year 2018	Year 2030
Option 3: Low cost waste treatment		
Collection rate – Urban (%)	97	100
Collection rate – Rural (%)	60-81	81
Collection Total (t/y)	710,932	1,056,402
Recycling (%)	10	20
Recycling (t/y)	71,093	216,034
Compost (%)	2	20
Compost (t/y)	14,219	211,280
Other treatment, RDF for cement industry (%)	44	30
Other treatment, RDF for cement industry (t/y)	312,810	314,544
Residual waste for landfill (%)	44	30
Residual waste for landfill (t/y)	312,810	314,544
Residual waste for landfill - Accumulated (t)		4,129,430

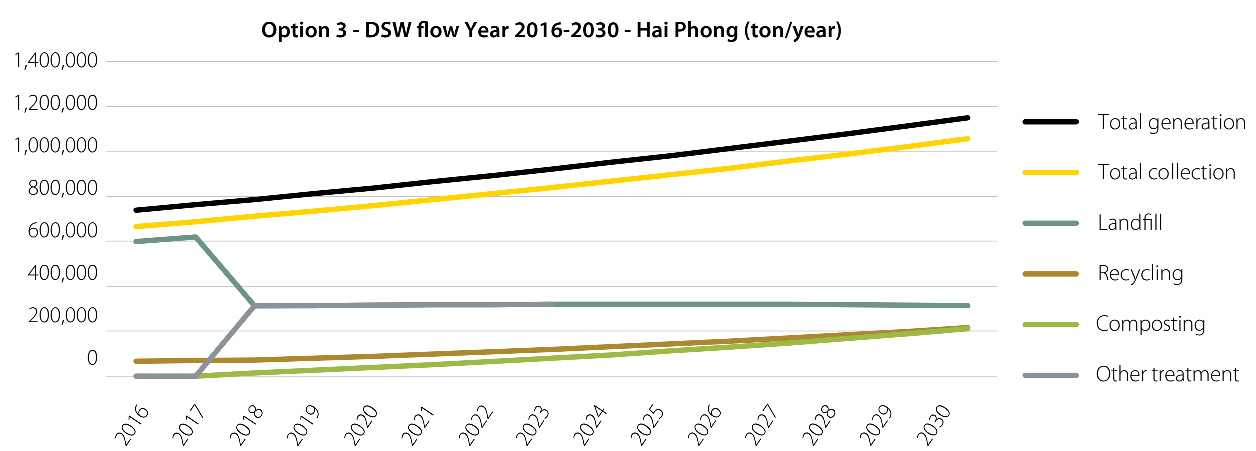


FIGURE 2-29 **Option/Scenario 3 – Low cost waste treatment – Hai Phong (ton/year)**

The necessary systems and facilities for the future handling of the waste are listed in Table 2-69 below.

The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11. In this scenario, the transfer stations are integrated with the MBT facilities. The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal system required in each of the four-year periods to 2030 are presented in Table 2-70.

The costs for collection are comparable to those under the first option/scenario, while the costs for disposal/treatment[38] are substantially higher due to the use of mechanical biological treatment systems. The advantage is that there is substantially less need for landfilling and landfills. The estimated operational and maintenance costs are presented in Table 2-71.

The mechanical biological treatment stations are rolled out which are also the main cost driver for operational costs as there is reduced need for new, environmentally sanitary landfills. Where, full cost recovery is introduced and all costs are to be covered by normal residents, the average costs per person would be as shown Table 2-72.

TABLE 2-69 **Option/Scenario 3, Hai Phong – Necessary equipment and facilities – Year 2018 – 2030**

Item	Year 2018	Year 2030	Comments
Option 3: Low cost waste treatment			
Transfer points in streets (No.)	1,788	2,017	1 per 1000 persons
Pushcarts/containers (No.)	1,731	2,573	0.75 m^3, 1 m^3, 5 loads/day
Compaction trucks for collection (No.)	72	107	15 m^3, 7.5 t; 4 trips/d
Transfer stations (No.)	0	0	Capacity each: 200,000 t/y
MBT facilities	4	7	Capacity each: 200,000 t/y
Other treatment, RDF for cement industry (No.)	0	0	Existing cement factories
New landfills (2 mln. tons capacity each)	1	3	

TABLE 2-70 **Option/Scenario 3 – Low cost waste treatment: Total investments estimated for Hai Phong for Solid Waste Collection and Disposal (US$)**

Option/Scenario 3	2018-2021	2022-2025	2026-2030	Total
Collection	10,318,000	1,751,000	3,707,000	15,776,000
Disposal	235,000,000	10,000,000	100,000,000	345,000,000
Total	245,318,000	11,751,000	103,707,000	360,776,000

TABLE 2-71 **Option/Scenario 3 – Annual operation and maintenance costs Hai Phong for Solid Waste Collection and Disposal (US$)**

Option/Scenario 3	2018-2021	2022-2025	2026-2030	Total
Collection	31,067,000	35,379,000	51,217,000	117,664,000
Disposal/treatment	116,000,000	134,000,000	216,000,000	466,000,000
Total	147,067,000	169,379,000	267,217,000	583,664,000

38 These costs exclude the costs of land acquisition, resettlement and taxes as these would need to be determined as part of a specific feasibility study analysis.

TABLE 2-72 **Option/Scenario 3, Hai Phong – Total average costs per person per year**

Option/Scenario 3: Low Costs Treatment	US$/person/Year	US$/Ton	VND/person/Year	VND/ton
Total investments and reinvestments	10.28	25.47	233,415	578,215
Total operation and maintenance costs	20.59	50.99	467,289	1,157,566
Total annual costs	**30.87**	**76.47**	**700,705**	**1,735,781**

The average salary in Vietnam is VND 4,845,000/ month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generates income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 21-31% of the average costs as presented above.

If the fees were to be increased to a level considered to be internationally affordable, this would still leave an annual financing gap of VND 482,680 – 555,355 per person per year, US$208- US$241 million per year.

Option 4 – Advanced treatment technologies

Also in this scenario, Mechanical Biological Treatment facilities are employed to mechanically separate the household waste, in order to separate the organic fraction for composing and a Refuse Derived Fuel fraction that is then incinerated in dedicated Waste-to-Energy plants.

As in the third option/scenario, this leads to an increase in recycling materials from the 71,093 tons per year to about 211,280 tons per year in 2030; 211,280 tons of compost would be produced in 2030 and 365,000 tons per year of waste would be incinerated. In this scenario, much less waste needs landfilling, from 625,620 tons per year in the beginning to 318,837 ton per year in 2030. The waste flow collected, recycled and landfilled in option/scenario 3 is presented in Table 2-73 below for the planning period from 2018 to 2030.

TABLE 2-73 **Option/Scenario 4 – Waste flow forecast Hai Phuong, Year 2018 – 2030**

Item	Year 2018	Year 2030
Option/scenario 4: Advanced treatment technologies		
Collection rate – Urban (%)	97	100
Collection rate – Rural (%)	60-81	81
Collection Total (t/y)	710,932	1,056,402
Recycling (%)	10	20
Recycling (t/y)	71,093	211,280
Compost (%)	2	20
Compost (t/y)	14,219	211,280
Waste-to-Energy (%)	0	35
Waste-to-Energy (t/y)	0	365,000
Residual waste for landfill (%)	88	30
Residual waste for landfill (t/y)	625,620	318,837
Residual waste for landfill - Accumulated (t)		5,466,610

The development of the waste flow within the planning period is further illustrated in the Figure 2-30 below. Amounts for landfilling are limited due to the significant positive impact from composting and the incineration of RDF in Waste-to-Energy plants.

The necessary systems and facilities for handling of the waste in future are listed in Table 2-74.

The costs of the equipment and facilities are based on the costs and price information listed in Table 2-11. In this scenario, the transfer stations are integrated with the MBT facilities. The investments in equipment and facilities that are needed for modernization of the collection, transport and disposal of waste required in each of the four-year periods until 2030 are presented in Table 2-75.

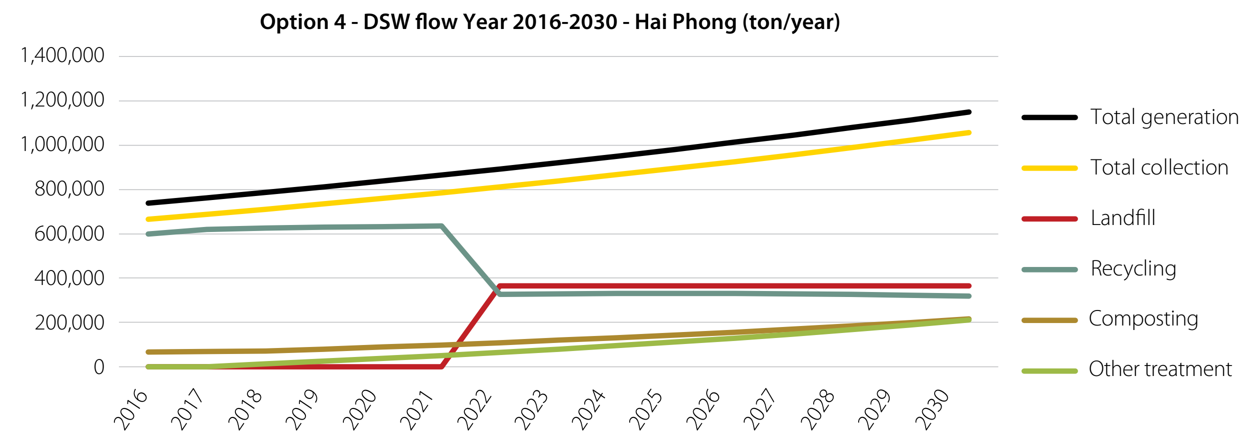


FIGURE 2-30 Option/Scenario 4 – Advanced treatment technologies Hai Phong (ton/year)

TABLE 2-74 Option/Scenario 4, Hai Phong – Necessary equipment and facilities, Year 2018 – 2030

Item	Year 2018	Year 2030	Comments
Option 4: Advanced treatment technologies			
Transfer points in streets (No.)	1,788	2,017	1 per 1000 persons
Pushcarts/containers (No.)	1,731	2,573	0.75 m^3, 1 m^3, 5 loads/day.
Compaction trucks for collection (No.)	72	107	15 m^3, 7.5 t, 4 trips/d
Transfer stations (No.)	0	0	Capacity each: 200,000 t/y
MBT facilities	4	6	Capacity each: 200,000 t/y
Waste-to-energy plants (No.)	0	1	Capacity each: 1,000 t/day
New landfills (2 mln tons capacity each)	1	3	

TABLE 2-75 Option/Scenario 4 – Advanced waste treatment: Total investments estimated for Hai Phong for Solid Waste Collection and Disposal (US$)

Option/Scenario 4	2018-2021	2022-2025	2026-2030	Total
Collection	10,318,000	1,751,000	3,707,000	15,776,000
Disposal	200,000,000	195,000,000	55,000,000	450,000,000
Total	210,318,000	196,751,000	58,707,000	465,776,000

The costs for collection are comparable to those under the previous scenarios, while the costs for disposal/treatment[39] are substantially higher due to the waste to energy plant. When compared to option 3, an advantage of this scenario is that there is substantially less need for landfilling and landfills, the disadvantage is that there is no RDF for the cement plants. The estimated operational and maintenance costs are presented in Table 2-76.

The mechanical biological treatment stations and waste to energy plant are the main costs driver for operational costs. In case, full cost recovery is introduced and that all costs are to be covered by normal residents, the average costs per person will be as shown in Table 2-77.

The average salary in Vietnam is VND 4,845,000/month. International norms indicate an affordable fee for waste management services of 1-1.5% of the average spendable income of the household. In cases where only one person generate income in the household, the affordable fee would be approx. VND 48,450-72,675 per month/household. With an average of 4 persons per household, the affordable annual fee per person would be VND 145,350 – 218,025. This only covers 18-23% of the average costs as presented above.

In case the fees would be increased to what is considered affordable internationally, this would still leave an annual financing gap of VND 575,799 – 648,474 per person per year, US$250- US$282 million per year.

Planning for future waste management improvements and related investments should be based on the availability of reliable information on waste quantities, composition, generation rates, and waste density in both urban and rural areas. Investment decisions need to be based on more detailed feasibility analysis, including more data collection and data verification. A key recommendation for provinces and cities that are planning infrastructure investments with or without the private sector is: to **budget the funds**

TABLE 2-76 Option/Scenario 4 – Annual operation and maintenance costs for Hai Phong for Solid Waste Collection and Disposal (US$)

Option/Scenario 4	2018-2021	2022-2025	2026-2030	Total
Collection	31,067,000	35,379,000	51,217,000	117,664,000
Disposal/treatment	106,000,000	168,000,000	232,000,000	506,000,000
Total	137,067,000	203,379,000	283,217,000	623,664,000

TABLE 2-77 Option/Scenario 4, Hai Phong – Total average costs per person per year

Option/Scenario 4: Advanced Treatment Technologies	US$/person/Year	US$/Ton	VND/person/Year	VND/ton
Total investments and reinvestments	13.08	32.39	296,854	735,365
Total operation and maintenance costs	21.89	54.23	496,970	1,231,090
Total annual costs	**34.97**	**86.63**	**793,824**	**1,966,455**

39 These costs exclude the costs of land acquisition, resettlement, taxes as these would need to be determined as part of specific feasibility study analysis.

required for a detailed feasibility analysis of solid waste management technologies, skills development, capacity building and monitoring/enforcement and to prepare the roadmap/masterplan on reginal level that can be the basis for selecting specific investments and technologies.

Required institutional and operational capacity building needs to precede even basic infrastructure upgrading, including improvements in revenue collection. Considering the current low capacities, substantial training and capacity building programs will be needed in areas of: (i) policy formulation and planning; (ii) legislation; (iii) infrastructure feasibility analysis and design; (iv) budgeting and accounting; (v) technical operation; and (vi) monitoring and enforcement. Sustainable private sector participation is viable when supported by appropriate legislation, regulations, monitoring, enforcement, increased waste fees and government capacity. The legal framework will also need to establish a transparent financing mechanism with cost-recovery targets from user fees and institute a system to enforce payments.

2.4 STRATEGIC ACTION AREAS FOR IMPLEMENTATION OF THE NATIONAL STRATEGY OF SOLID WASTE MANAGEMENT

Gradually implementing a modern, integrated and sustainable solid waste management system at an affordable cost will require changes across different areas and levels, including: (i) solid waste management infrastructure and operational practices; (ii) financing and cost recovery; (iii) legislative and regulatory framework; (iv) institutional arrangements nationally, regionally and locally; (v) public awareness and participation; and (vi) institutional capacity building. This chapter will identify the requirements in each of these key priority action areas in order to achieve the solid waste sector system improvements that are foreseen in the National Strategy on Solid Waste Management.

2.4.1 DOMESTIC SOLID WASTE FORECAST FOR VIETNAM

Management of Domestic Solid Waste generated by households and similar waste from commercial/ institutional/ industrial entities is characterized by two distinct elements, namely: (i) the large waste quantities produced daily by the mega cities (especially Hanoi and HCMC) and (ii) the fine-grained and labour-intensive collection, separation and treatment system including the informal sector dominating the market for recyclables. Strong economic and population growth, and urbanization magnify the problems and waste quantities are growing rapidly each year. This development is illustrated in Figures 31 and 32 below, which show the expected development in the total population and the solid waste generation in Vietnam to the year 2030. As it can be seen from the figures, the current trend of urbanisation is expected to continue rapidly. By 2023 there are forecast to be more people living in urban areas than in rural areas. At the same time, waste generation will continue to grow rapidly, especially in urban areas, due to increased urbanisation and due to a growing waste generation per capita.

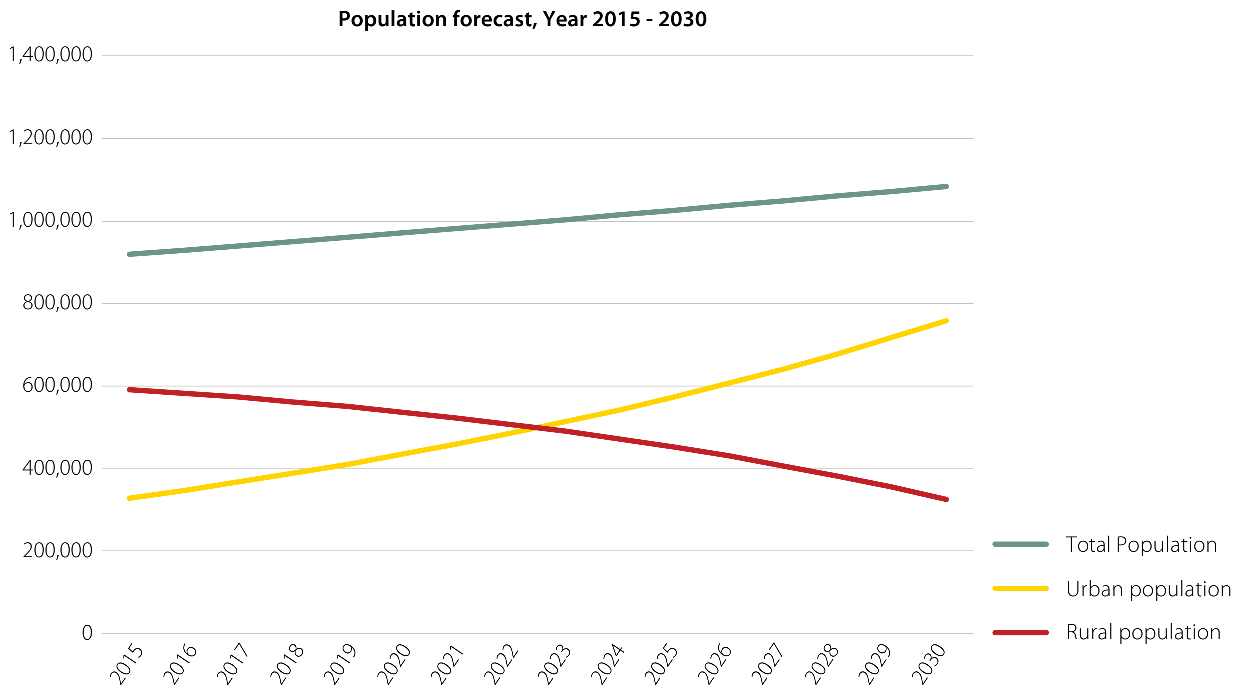


FIGURE 2-31 **Population Forecast, Vietnam, 2015 – 2030**

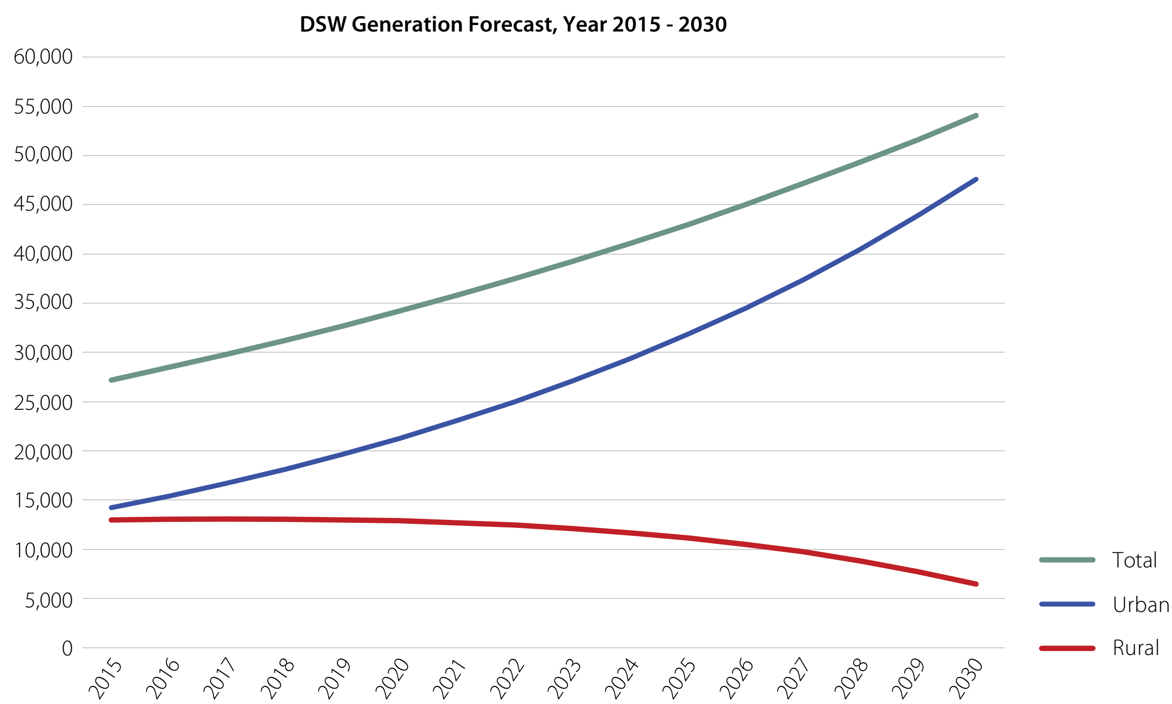


FIGURE 2-32 **Domestic Solid Waste Generation Forecast, Vietnam, 2015 – 2030**

The forecast for Domestic Solid Waste generation to 2030 for the urban and rural population in Vietnam as well as the average annual growth rate is presented in Table 2-78 below.

2.4.2 SOLID WASTE MANAGEMENT INFRASTRUCTURE

Collection and transport

Domestic waste collection coverage should increase according to the revised National Strategy (Decision 491/2018) to cover the total population and decrease the risks of illegal dumping, starting with urban areas and then expanding to include sub-urban and rural areas. Service coverage can be improved by enhancing the operational efficiency of provincial/city URENCO's and private companies or rural Cooperatives and/or by investing in hardware, such as trucks and containers, trolley, waste collection bikes and training of staff.

Operational costs for waste collection and transport are high especially due to the prevalence of small streets requiring lots of collection workers equipped with pushcarts and relatively small waste collection trucks to transport the waste over large distances to landfills without the use of transfer stations.

In addition, a decision must be taken on the wide introduction of containers. Currently the households are delivering their waste in small plastic shopping bags on a daily basis. Average usage is 35 bags/week/household. The introduction of containers will increase the cost/ton. While the current collection system is labour intensive and expensive, it does

TABLE 2-78 **Forecast DSW generation and collection for all of Vietnam**

	Year			Average annual growth rate
	2015	2018	2030	
Population				
Total	91,972,000	95,043,000	108,390,000	1.1%
Urban	32,834,000	38,819,000	75,843,000	5.7%
Rural	59,138,000	56,225,000	32,547,000	-5%
Domestic Solid Waste Generation (t/y)				
Total	27,181,000	31,188,000	54,056,000	4.7%
Urban	14,230,000	18,116,000	47,582,000	8.4%
Rural	12,951,000	13,072,000	6,474,000	-8%
DSW generation (kg/cap/d)				
Total	0.81	0.90	1.37	
Urban	1.19	1.28	1.72	
Rural	0.60	0.64	0.54	
DSW collection rates (%)[40]				
Total	66%		94%	
Urban	90%		100%	
Rural	40%		50*	

40 This is based on the forecast that by 2030 all waste will be collected in urban areas, whereas only 50% is expected in rural areas. As rural population is rapidly decreasing, this will only have a limited impact on the total quantities collected.

offer a high service to inhabitants as waste is removed from streets at least once per day even though people just place a small plastic shopping bag randomly on the streets. As this system has been practised for many years, it cannot be changed overnight. This labour intensive collection system will continue for some years, until it can be fully replaced by a more modern system including door-to-door collection and the use of individual bins/containers for each household. Other collection systems will require more active involvement of inhabitants and containers to be provided to each household and will need to be followed up by massive information and awareness raising campaigns – both before and after implementation. Stationary (4-wheeled) containers with volumes of approximately 1 m^3 are to be used more widely in the future, starting with collection of waste from high-rise residential buildings, offices, shops and other large individual waste generators.

Specific transfer points should also be established by construction of asphalted or concrete paved areas integrated in the sidewalks, next to the streets. The areas should be large enough for temporary parking of the necessary number of pushcarts during the time between primary and secondary collection. The transfer points shall be cleaned/maintained by collection workers.

In the future, the secondary collection and transportation should also be carried out by means of compaction trucks that can empty the pushcarts. In general, larger trucks should be used where possible, such as for example 15 m^3 trucks. The use of larger trucks is more appropriate given the often-long transport distances and/or transport times. To improve the efficiency of the secondary collection system, transfer stations should be implemented.

Transfer stations

The purpose of waste transfer stations is to increase efficiency and thereby reduce the cost for transportation of collected waste to a landfill or treatment facility by transportation in vehicles with large capacities and reduced transportation costs (cost/ton/km) compared to smaller vehicles used for waste collection in the districts – and at the same time to reduce the impact from transportation on the environment.

All collection vehicles have an operational radius within which they are cost effective and the transfer station can be used to assist in maintaining the overall efficiency of the waste collection system. Based on experience, as a rough rule of thumb, the use of transfer stations should be considered if transport time is more than ½ hour or if the distance is more than 30 km. A detailed analysis is needed in each individual case, as the relevance of waste transfer depends on specific conditions, such as road quality, waste quantities and composition etc.

Transfer stations can be established and operated for transfer of waste to the landfill or treatment facility, but they can also be integrated in treatment facilities such as MBT-plants for example, in case such facilities are included in the system.

Recycling

About 10% of the DSW is currently recycled. Recycling activities are rudimentary and dominated by the informal sector before the waste enters the formal collection channel. Wholesalers are buying from the informal waste collectors and in some cases from the formal sector (URENCO's). The informal sector separates, bales and sells the products to the processing industry. Processing of recyclables is to a large extent carried out in craft villages without proper regulation, monitoring and enforcement of proper operating practices. These activities lead to substantial pollution of air, water and land and serious health hazards for the workers. At the same time, craft villages provide considerable employment.

The informal sector is expected to play a role in recycling in the future. Therefore, increasing recycling and reuse activities should ideally be progressively taken over and controlled by the official waste management sector. Proper working conditions for workers must be ensured and materials must be adequately handled to ensure a high degree of recycling and a minimum of impact to the environment.

Treatment

The high organic content calls for relatively simple, affordable treatment solutions, such as compost or biogas production, as this would take out a large percentage of the waste that would otherwise occupy space at the already overloaded landfills. Production of quality compost that can be utilized in agriculture requires source separation of organic waste at major sources (e.g. markets, food shops, and eventually also at individual households). Source separation of organic waste fractions should be introduced progressively, first through pilot projects focusing on major organic waste sources and then at ward/community level and eventually, nationwide.

(Ningbo, China) Household Waste Biogas and Recycling Project

In August 2016, Ningbo established Special Purpose Vehicle (SPV) company, named Ningbo Capital Kitchen Waste Treatment Co. Ltd., jointly with a Chinese investor and the Ningbo Municipal Investment Co. with a 60/40 percent share between the two parties (60% for the investor).

The City entered into legal agreements for the SPV to invest, design, construct and operate the Kitchen Waste Treatment Facility (KWTF) for 20 years (including 2 years of construction) with provision to expand the capacity of KWTF from 400 tons per day to 800 tons per day.

The expected total investment is around CNY 310 million (US$49 mln), with 30% funding from capital (equity) raised from the shareholders; around CNY 147 million (US$23 mln) paid from a World Bank Loan and the balance raised from commercial financing.

The SPV will get paid via gate fees and revenues from the sale of biogas, the sale of recyclables/compost and wastewater treatment fees to recover investments, operating costs and other costs such as waste disposal charges. Assets can be transferred to the City at the end of 20-year concession period.

China – Ningbo Household Waste Recycling Project

PPP arrangement for kitchen waste treatment

The City of Ningbo is introducing waste separation at household level with near 3 million people. The largest waste stream (60%) consists of kitchen waste. With World Bank technical and financing support a JSC has been established with 60% private equity to construct and operate a $24.5 million anaerobic treatment facility to process the kitchen waste and generate heat and electricity.

Mechanical Biological Treatment

Waste composition shows a high content of organics (50-80%), a relatively low content of dry recyclables (10-25%) and a high content of inert waste (probably coming from street sweepings) of 15-38%. The energy content is low i.e. 900-1,200 kcal/kg or 3.6-4.8 MJ/kg (waste incineration or Refuse Derived Fuel production from waste needs at least 7 MJ/kg). The low content of recyclables is due to the informal sector/private entities collecting the most valuable materials before the waste enters the waste container.

Therefore, separation of waste is needed to allow production of Refuse Derived Fuel that could be used as a fuel either in waste to energy plants or co-incineration at cement plants. While gradually improving household source separation, mechanical biological treatment systems can be included to separate the fractions coming as mixed waste from households. Mechanical Biological Treatment systems have the following common features: (i) Reception of mixed domestic waste or similar waste at a reception facility; (ii) Initial size reduction and sorting into a fine and a coarse fraction (sometimes more than two fractions); (iii) The fine fraction that generally contains more organic matter undergoes an aerobic or anaerobic (or combination thereof) treatment. The main output from these processes is compost that can be used in agriculture, provided that the quality meets the standards. If the quality is too poor for agriculture, the compost can be used as part of daily and final cover materials on landfills; and (iv) After further separation (sieves, magnets, reverse slope separation, etc.), the coarse fraction that generally contains more plastic, wood, paper etc. is converted to RDF for use as fuel in waste-to-energy plants or co-incinerated together with traditional fuels in cement plants. Recyclable fractions may be further processed by the recycling industry. Any residual waste must be landfilled.

Incineration, Waste-to-Energy plants

Incineration is an option used by several countries to reduce the amount of solid waste requiring disposal to landfill, and to recover energy in the form of heat and/or electricity. Countries where incineration is widely used are typically countries where available land for landfilling is limited and landfill gate fees high. For waste to be suitable for incineration, a large part of the organic fraction would need to be removed for the waste meet the calorific values required (typically more than 9,000 KJ/kg) and therefore MBT technologies would be required to produce suitable RDF. In order to avoid air pollution by incinerators, substantial and costly air pollution abatement units are required.

Even though a certain cost reduction can be obtained by selling electricity and in some cases also the excess heat generated by incineration plants, incineration remains much more expensive than other treatment technologies and should in general not be considered a stand-alone-solution, especially not for low and middle-income countries, if the electricity feed-in fee is too low.

In the Vietnamese context incineration can be considered a part of the future waste treatment solution, in combination with other less expensive technologies, such as composting of the organic fraction. This combination could result in substantial reductions in the remaining waste amounts that eventually need to be landfilled. However, this process does require significant funding to obtain technologies that do not pollute the air. Waste reduction is an important aspect for a country, where only very limited areas are left for new landfills. But as with reduction, reuse and recycling options, gate fees for landfill disposal need to be sufficiently high for other more expensive treatment systems to become viable.

Production of Refuse Derived Fuel for Co-incineration at cement plants

Cement kiln co-incineration can be much cheaper than dedicated new incineration plants as the cement plants are already existing throughout Vietnam and they would likely be willing to co-incinerate the RDF for a lower fee than would be applicable through dedicated incineration plants. Plastics are a key component of the RDF and will therefore contribute to the problem of plastics “leaking” into the rivers and oceans.

Typically, there is a large range in terms of payment, from the low end where the supplier of the RDF receives US$ 30/ton to RDF suppliers having to pay US$ 30/ton, depending on market conditions and quality of the RDF and the ability of the cement plant to receive and use the RDF.

Co-incineration can also play a sizable role in Vietnam's NDC commitment, as replacement of primary fuel by RDF represents a reduction in CO_2 emissions.

This potential for cement kilns to use RDF as co-incineration warrants further investigation to analyse the investment required at industry level, the key waste streams that have the potential to be priority waste streams for AFR, the market potential as well as key bottlenecks and the possible Greenhouse Gas Emission Reduction and potential for cooperation with the private sector. The key priority waste streams are: (i) RDF from municipal waste, (ii) dried sewage sludge; (iii) tire derived waste; (iv) persistent organic pesticides; and (v) Polychlorinated biphenyl (PCBs).

This is being supported by the World Bank under the NDC partnership facility and the draft report will be available for presentation and discussion in late 2018.

Landfilling

Landfilling is by far the prevailing waste treatment or disposal solution in Vietnam. About 60-70% of the waste that is collected, is disposed of at official landfill sites not compliant with international and national design standards. According to the national standards, a sanitary landfill should be comprised of different cells with appropriate lining, cover and gas collection system, and include buffer zones and auxiliary works such as water treatment stations, waste gas treatment stations, power and water supply stations, weighing stations, executive offices and grades. In addition, the landfill sites are in general poorly operated. Landfills occupy valuable land and represent a real hazard to people and the environment, creating large gas emission risks, air pollution and unintended Persistent Organic Pollutants release due to landfill fires and large amounts of leachate water to be treated, mainly in open ponds which are also filled with rainwater during the heavy rainy season.

Despite this, landfills are certain to remain the prevailing waste disposal method in Vietnam for at least the next decade as landfilling is the cheapest disposal option. Without substantially greater financial resources in the waste sector, implementation of more advanced treatment technologies will take time. Even with more advanced treatment technologies, there will still be a substantial need for continued operation of existing landfills and for construction and operation of new landfills. Landfills must be planned, designed, constructed and operated in a proper way with sufficient monitoring and enforcement, to ensure that they do not contaminate the environment.

Identifying suitable sites for new landfills will be challenging given the high population density in and around the large cities and urbanised areas. Therefore, in addition to identifying new landfill sites, the potential for extension of existing landfills and/or construction of new landfills next to existing disposal sites, should be investigated.

2.4.3 LEGAL AND INSTITUTIONAL

Identifying appropriate solutions to the large and rapidly increasing nationwide solid waste management problem requires dedicated waste management planning. Adequate human resources should be provided for this purpose with adequate capacity building.

Substantial improvements in waste service levels, introduction of environmentally sustainable disposal operations and new advanced treatment and waste reduction technologies are typically only viable with substantial enforcement and reform of the institutional and regulatory framework. The lack of adequate control and enforcement and insufficient legislation are contributing to the environmental problems and aggravating health risks for the population.

Detailed Solid Waste Management targets, norms and minimum standards need to be clearly defined in the legal framework against which the different parties can be held accountable. This will require substantially more detailed plans than are currently prepared by central authorities and also issuance of guidelines and decrees. In addition, sufficient funds must be allocated for new infrastructure and waste fees must be increased to cover costs (see below).

Streamlining of responsibility for solid waste management is required at the national level as well as clear assignment of competences and responsibilities between the PPCs, CPCs, DOCs, DONREs and the URENCOs. There is also a need to professionalize the solid waste enterprises and generally increase waste management planning capacity at national, regional and local levels. A common recommendation is to separate the administrative/planning functions from operations in order to create greater accountability and avoid service providers monitoring their own performance, as is currently the case.

Compliance with the established norms and standards needs to be enforced by transparent sanctions and independent supervision and enforcement. The legal framework should also establish clear cost-recovery targets and form the basis for enforcing payments from households and other waste generators.

There is a need to introduce accounting systems to record the amounts of waste generated and landfilled as well as the composition of the waste. Collecting this data will enable the preparation of waste statistics that can inform planning for modernization and advanced treatment technologies.

While details and specific targets for a gradual solid waste improvement strategy can be introduced through a phased approach, sustainable improvements to the solid waste system, require policy and institutional decisions to address the key legal, regulatory, institutional, financial and capacity building actions needed to plan and adequately improve the solid waste management system.

An example of a suitable approach is the Project in Indonesia on “Improvement of Solid Waste Management to Support Regional and Metropolitan Cities, which is to be financed by a US$100 million Loan from the World Bank and is expected to be approved by the World Bank in October 2018. The Program’s objective is to improve solid waste management services for urban populations in selected cities across Indonesia. Key components for the improvement of SWM are: (i) institutional and policy development; (ii) integrated planning support and capacity building for local government and communities; (iii) solid waste infrastructure in selected cities; and (iv) implementation support and assistance. Details on the structure of the loan, its expected results and facilitation for technical capacity building and private sector engagement are presented in the box next page.

Indonesia – National Solid Waste Management Sector Development Project

In the last 15-20 years, Indonesia has embarked on multiple efforts from the central government to improve performance of (domestic) waste management services in the country. Actions mainly took the form of national sector strategies and plans and investment support to cities for downstream waste facilities, mainly landfills and recycling centers. Results have been poor, the country has only a handful of adequately managed waste disposal facilities, formal recycling is around a few percent and at least 30% of the total urban waste is yet not collected.

Since 2017 the Government of Indonesia has, with support from the World Bank, been concluding preparations for a development program for the waste sector based on approaches that have proven to be successful for other sectors, such as water supply and slum upgrading. The program has a heavy investment component but is particularly designed to manage critical sector issues that thus far obstructed sector development. Preparation and implementation follow some key steps:

1. Preparations started with the analytical work and the development of a comprehensive Sector Roadmap. All 104 cities in the country were analyzed to assess waste management performance (collection rates, recycling percentages, quality of disposal), but also investment needs, operational budgets, and investment budgets. This resulted in an unprecedented database with detailed information by city; various models to develop waste management systems to achieve universal waste collection and waste reduction rates of 30%. The analytical work also allowed for the identification of five key sector development challenges: (1) lack of operational financing in cities; (2) lack of operational capacity to run waste management systems; (3) challenges in primary waste collection which in Indonesia is mainly organized by communities (and not the city administration); (4) poor regulatory oversight, performance monitoring and enforcement are lacking at every level; and (5) land issues to develop waste facilities.

2. Analysis of available investment funding, which has been estimated at US$ 1.2 billion from national and local budgets including donor funding, for the period 2018-2022; estimates exclude private sector funding.

3. Creation of a multi-stakeholder sector development platform with key government agencies and donors.

4. Design of an implementation program based on available public funding, addressing the five key sector challenging and maximizing private sector funding. To achieve these goals, the program focusses on 46 cities which have been categorized through the analytical work, as the most committed and ready to receive technical and investment support. The program has 4 components; (1) National policy and institutional capacity, US$ 5 million; (2) Technical support program for participating cities, US$ 56 million; (3) Investment program US$ 1.1 billion public funding, expected to attract at least US$ 1.5 billion in private sector funding; and (4) Budget for Program management, progress monitoring and evaluation, US$ 15 million. The implement this program, the Government of Indonesia is preparing a Loan from the World Bank of US$ 100 million of which US$ 45 million will contribute to the investments under Component 3 and the remaining US$ 55 million will be allocated for Technical Assistance under the Components 1, 2 and 4.

5. Implementation of the program is expected to start in the second half of 2019.

The informal sector is a major actor in waste management, and the social aspects are important as this concerns the livelihood of a group of vulnerable citizens. Waste pickers may be integrated in the sanitary landfill operation concept[41] or through improvements in recycling for instance through manual sorting at a Material Recovery Facility.

2.4.4 COSTS AND WASTE FEES

To establish a rough estimate of the total cost implications for all of Vietnam for a significant improvement of domestic waste management on the basis of option/scenario 3, the findings from Hanoi, Phu Tho and Hai Phong that represent about 12% of Vietnamese population, have been extrapolated to cover all of Vietnam. The total number of facilities and equipment is based on the rough estimate of equipment and facilities that would be required nationwide based on option three that includes Mechanical Biological Treatment facilities.

Total investment costs for all of Vietnam for introducing modern solid waste systems, including mechanical-biological treatment facilities are estimated to total US$ 13 billion by 2030. This estimate excludes operational costs which are estimated to be growing to US$ 2.2 billion annually. These modernized solid waste systems will include new waste collection equipment, transportation trucks and transfer stations placed at mechanical biological treatment facilities where waste is mechanically separated and biological treatment of organic waste fraction takes place. Refused Derived Fuel (plastics, paper, carton etc) is produced at these facilities which can be incinerated[42] and the residuals disposed of in sanitary landfills with liners, gas collection, leachate collection and treatment, in line with international standards.

Option 3 results in average costs per person, per year in the order of US$ 20 or VND 470,000. As these costs are much higher than currently covered by waste fees (which are 26,500 VND per household per month or 79,500 VND per person per year), substantial fee increases will be required. The affordable annual fee per person based on internationally determined benchmarks of 1% - 1.5% of household income would be VND 145,350 – 218,025, which would still cover only 31%-47% of the costs and would therefore require substantial further financing/ subsidy from cities and provinces.

The revenues for public waste collection companies consist of income from fees, subsidies from the CPC and from various services such as collection and treatment of specific waste fractions. The fees for waste collection, disposal and treatment to be paid by households and the commercial entities are prepared by the People's Committees at the level of Districts, cities and towns. Fee proposals are submitted by the waste collection companies to the People's Committees of the centrally controlled Municipalities (Hanoi, Ho Chi Minh City, Hai Phong, Da Nang, Can Tho) and to the Provincial People's Committees (58) for final approval. This process results in fees that are different in the various municipalities and in the cities and towns at the District level. All fees are based on operational costs only and exclude any amortization on investments. The People's Committees at Municipal and Provincial level pay for the amortization costs and for any shortfall in the operational costs.

41 If allowed at the sanitary landfill, the waste picking should be contained to a very specific area and a specific time-period between unloading of the waste and compaction. In such schemes, the workers should be provided with protective clothing and access to proper toilets and washing facilities and be offered regular medical checks.

42 Potential fees for cement plants for co-incineration are not included in cost estimate; however, if the RDF meets the specifications of the plants then it could be without charge.

Consequently, domestic waste management in Vietnam lacks the "polluter pays" principle with low fees to be paid by households and other waste generators and at least 80% of the costs is being financed by the Government. Large or long-term investments in solid waste management facilities and systems are also hampered by the lack of proper financial mechanisms, such as long-term financial planning, savings for future investments and re-investments and return of investments, etc.

The current user fees for waste management services are insufficient and can only partially cover the annual operation costs at URENCO's and other operators. If user fees were to be increased and the collection of fees were efficient, it seems possible that at least the costs of basic waste management systems could be covered through user fees. In many cases, a fee system with different fees for different user groups already exists, allowing private businesses, public institutions etc. to cross-subsidise a large part of the costs and in this way lower the burden on the most vulnerable, low income portion of the population. This low level of revenue also reduces private sector interest in the solid waste sector.

As part of planning for modernization of solid waste infrastructure and specifically for the inclusion of more advanced (and therefore expensive) treatment technologies, it is imperative to set realistic cost recovery targets. At least part of the operating, investment, and remediation costs would need to be recovered from user fees and this requires adequate fee levels. The ability and willingness to pay for improved services has to be considered when developing a waste management strategy in order to keep costs at an acceptable and affordable level. In principle, user fees should initially cover the operating costs of the waste management system, and transfers and subsidies can be required during a transition period when investing in more modern and advanced systems, in order to manage a gradual increase in fees. Low income groups which cannot afford full fees would need support in form of targeted subsidies.

Given the financing constraints, it is necessary to implement improvements in a phased approach. It is unsuitable and unsustainable to leapfrog from the existing simple system into advanced modern and expensive solid waste management systems, based on high technology collection, treatment and disposal facilities. A phased approach allows for incremental improvements that are affordable, that create the basis for further scaling-up in the future, and which attract private sector interest to operate and invest in the system. The necessary institutional changes need to precede even basic upgrading, including improvements in revenue collection. Detailed and preferably regional waste management plans need to guide implementation. Private sector participation can be considered where analysed to be viable and supported by appropriate legislation, regulations, monitoring, enforcement and government capacity.

2.4.5 PRIVATE SECTOR PARTICIPATION

In the current solid waste management system, there is a lack of economic and financial incentives for private sector investment. Basic principles of Solid Waste Management Financing are not in place. There is an unclear regulatory framework, inconsistent enforcement of regulations, lack of reliable waste data, low fees and lack of unified fee setting (which should preferably take place at the national level), low revenue collection rates and unclear long-term budget allocation. The presence of more advanced treatment technology is insufficient, recycling rates are low, and the recycling sector is dominated by informal waste pickers. Overall, the sector is broadly underfunded and would currently not meet the costs of private operators. Given the fragmentation and small-scaler operations, economies of scale are low. In addition, skills and capacities of contracting public sector entities at the local and regional level are insufficient which hampers both procurement of services from the private sector as well as monitoring and enforcement of performance.

Some experience of establishing joint stock companies by city- or provincial authorities is available, although they are all controlled by the public entities, who own the majority of the shares. Therefore, for waste collection, there is only limited private sector involvement in the provision and improvement of waste management services and establishing of competition of the monopoly currently held by URENCO and other state-owned enterprises.

Several preconditions must be fulfilled before private sector participation may be introduced successfully:

1. Detailed legislation on solid waste management must be prepared and introduced, including proper definition of the duties and responsibilities of all stakeholders, i.e. the responsible authorities (ministries, provinces, cities) and waste producers (inhabitants/households, institutions, private companies etc.). Legislation should include detailed rules and decrees on how waste must be handled at source, during collection, transportation, treatment and/or final disposal.

2. The relevant legislation must be enforced, meaning that competent authorities must control waste management at the various stages from the point of generation until final disposal and fine those who do not respect the laws.

3. There must be a proper contractual basis for involving the private sector at the various stages of solid waste management. For example, collection and transportation services must be tendered according to minimum 5-year contracts, which will enable private operators to write off investments in collection and transportation equipment. For large private investments in treatment facilities, longer concession agreements of e.g. 15-20 years duration should be established. Fixed prices and contractual conditions must be ensured during the entire contract/concession period.

4. The responsible authority – e.g. the province or city must possess the necessary institutional (organizational capacity and skills to control the establishment and proper management of any agreement on private sector participation). This includes availability of staff with relevant education and experience.

2.4.6 CONTRIBUTION OF THE SOLID WASTE SECTOR TO NDC COMMITMENTS

Waste management is one of the four key sectors to contribute to the mitigation of GHG emissions as determined by the Intended Nationally Determined Contribution by Vietnam. The key foreseen measures to be taken in the waste management sector are: (i) develop waste management planning and enhance waste management capacity; promote reducing, reusing and recycling of waste; (ii) research and apply advanced waste treatment technologies, strengthen management and treatment of industrial and household wastewater; and (iii) utilize landfill gas and solid waste combustion for power generation.

The following alternative waste handling and treatment methodologies, waste prevention and recycling are potent strategies for reducing greenhouse gas emissions:

› (Co)-incineration of waste will reduce methane emissions from landfills due to less waste being disposed and replacement of other fossil energy sources due generation of electricity (and heat - if it can be used);

› Composting of organic degradable waste in e.g. windrows. Decomposition of organic degradable waste under aerobic conditions instead of anaerobic conditions in a landfill;

The third area of the NDC commitment in the solid waste sector on the potential for solid waste combustion and landfill gas utilization is detailed below.

Cement co-incineration of the Refuse Derived Fuels

As indicated, cement kiln co-incineration can be a much cheaper alternative to dedicated new incineration plants as the cement plants already exist throughout Vietnam and they would likely be willing to co-incinerate the RDF for a lower fee than would be applicable through dedicated incineration plants.

Co-incineration can also play a sizable role in Vietnam's NDC commitment, as replacement of primary fuel by RDF represents a reduction in CO_2 emissions. Plastics are a key component of the RDF and will therefore contribute to reducing the problem of plastics "leaking" into the rivers and oceans.

This potential for cement kilns to use RDF as co-incineration warrants further investigation to analyse the investment required at industry level, the key waste streams that have the potential to be priority waste streams for AFR, the market potential as well as key bottlenecks and the possible Greenhouse Gas Emission Reduction and potential for cooperation with the private sector. This is being supported by the World Bank under the NDC partnership facility and the draft report will be available for presentation and discussion in late 2018.

Landfill gas collection and utilisation

The anaerobic decomposition of waste in landfills produces methane, a greenhouse gas which is 21 times more potent than carbon dioxide. Burning of waste in dumps produces carbon dioxide as a by-product (and can create other kinds of undesirable environmental gases but typically not GHG gases). However, the latter is often of small scale and difficult to assess and estimate.

Landfill gas emission from landfill activities cannot be avoided. Shortly after waste has been disposed of the anaerobic digestion process begins and will result in methane emissions through the waste at the tipping front or through other pathways. Efficient collection of landfill gas will not be practical before a final top cover or a temporarily cover is in place at a specific disposal cell. In the initial phase of landfill operation, flaring is the only possible option for handling and treatment of the landfill gas that may be collected before the disposal cell has been closed and provided with a proper cover.

Landfill gas typically consists of 40-60% methane (CH_4) and 30-50% carbon dioxide (CO_2) plus nitrogen (N_2), oxygen (O_2), hydrogen (H_2) and different trace elements.

Huge amounts of DSW with high organic content is landfilled in Vietnam and there is a very high generation of landfill gas. A significant reduction in the release of landfill gas to the atmosphere and an equivalent CO_{2eq} emission reduction on landfills in Vietnam can be obtained by one or more of the following methods:

› Collection and flaring of methane;
› Utilisation of collected landfill gas in a gas engine and generator for electricity generation (replacement of other fossil energy sources);
› Collection of landfill gas for direct use in external facilities such nearby industries;
› Oxidation of methane in for example compost beds (large containers or specific

designed "windows" in landfill top cover where collected landfill gases pass through and where the methane fraction is oxidized (to CO_2 and water) by microorganisms). (A humus layer on top of a landfill will also, to some extent, oxidize the methane however it is difficult to secure regular infiltration through the top cover and it is (almost) impossible to measure).

To provide a rough overview of the potential for reduction of landfill gas emissions and the utilisation of the energy content in the gas, the following calculation has been made for the whole of Hanoi, as an example, based on the following assumptions:

- Organic waste component: 50% in 2018, decreasing to 25% in 2030
- Landfill gas collection rate: 20% in 2019 increasing to 70% in 2030
- Energy content in landfill gas: 4.44 kWh/ Nm^3 (50% CH_4)
- Electricity production is calculated based on 80% utilisation of collected landfill gas and an electricity production efficiency of 40% -> total utilisation of 32% of the collected gas.
- CO_2 equivalent is 21 times CH_4
- Gas collected but not utilised in a gas engine will be flared (i.e. all collected gas will be burned).
- Only waste landfilled within the period of 2018 – 2030 is included in the calculations.

The results of the calculations estimate potential total landfill gas collection of 10,000 Nm^3/hour, equal to 90 mln Nm^3/year; the details are presented in the Figures 2-33 and 2-34 below, including the key CO_2 reduction and electricity production:

1. Potential greenhouse gas reduction: 1.5 million tonnes CO_2 eq/year

2. Potential electricity production: 150,000 MWh/year

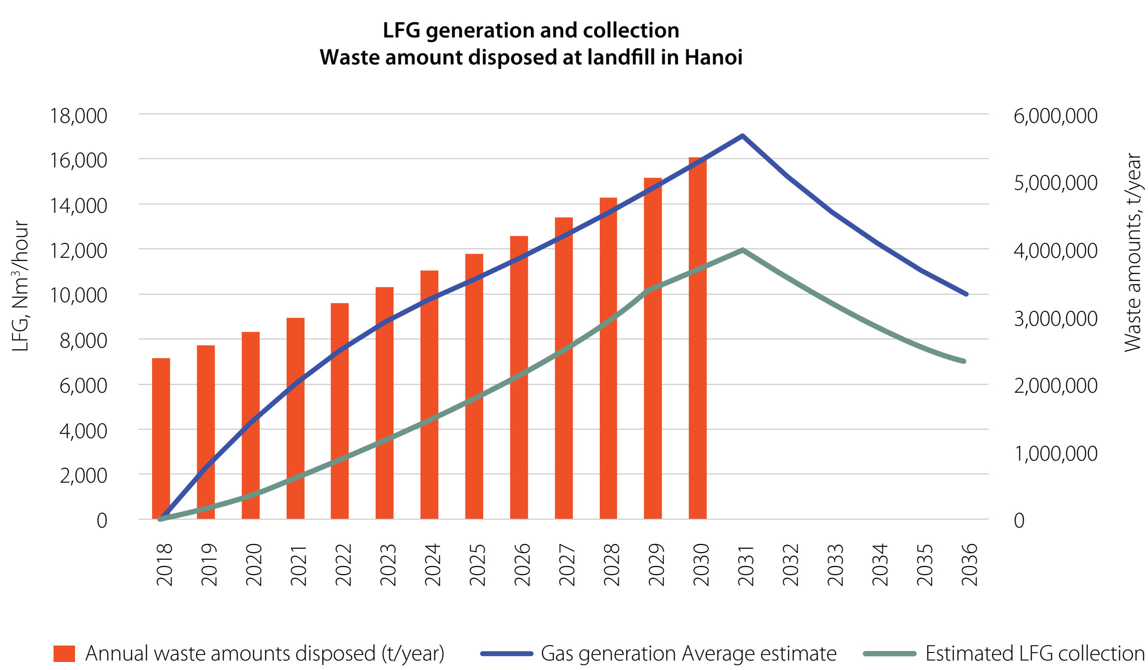


FIGURE 2-33 **Landfill gas generation and collection from landfills in Hanoi**

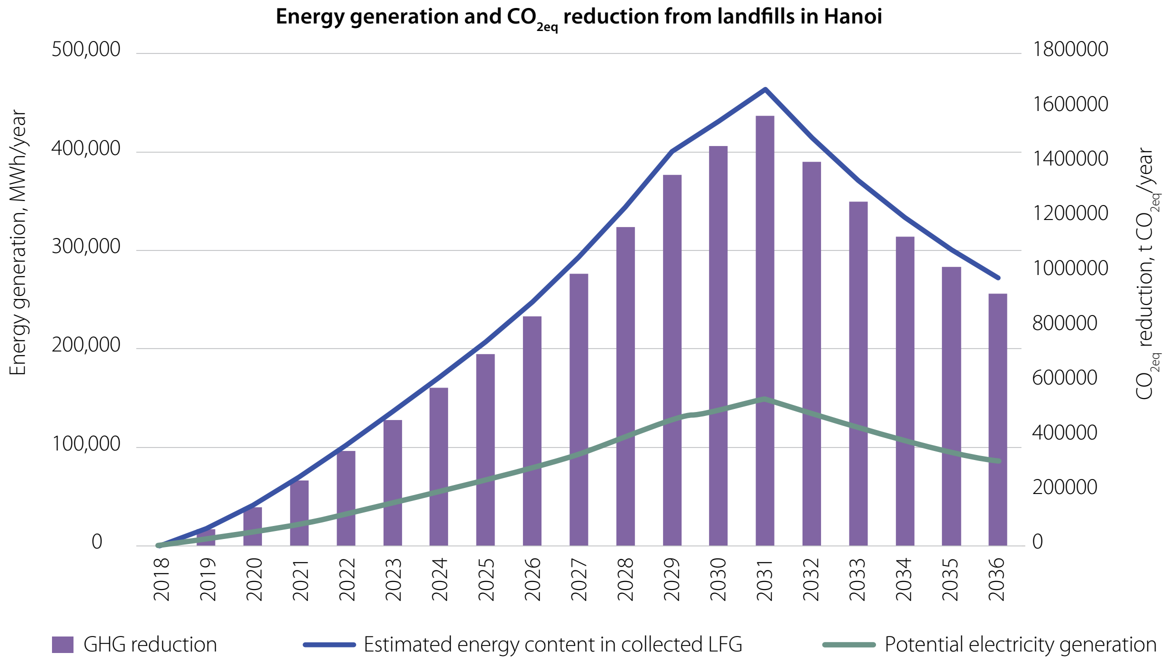


FIGURE 2-34 **Potential energy generation and CO_2 reduction from landfills in Hanoi**

If the gas from landfills in Hanoi could be utilised in gas engines for electricity production, it would require a total investment of at least US$ 20 million. The revenue from the sale of electricity could recoup part of the operation and maintenance costs. However, in general there is no large potential for a net profit from a landfill gas utilisation plant and the main driver for establishing gas collection systems at landfills, combined with flares and/or power generators should be the reductions of Greenhouse Gases.

3 PART B: INDUSTRIAL HAZARDOUS WASTE

3.1 INTRODUCTION AND OBJECTIVE

The assessment of industrial (hazardous) waste management covers the following waste types and provinces:

- Mining waste in Thai Nguyen and Bac Kan
- Sludge from major Wastewater Treatment Plants
- Waste from large industries in the province of Binh Thuan

It was agreed with DONRE in Thai Nguyen, to assess the industrial waste from the steel producing industry as well as the waste from the electronic producing industry. The assessment includes an inventory, assessment as well as definition of treatment and policy options for the specific industrial (hazardous) waste streams under study.

3.2 WASTE FROM MINING, STEEL PROCESSING AND ELECTRONIC INDUSTRY

3.2.1 MINING, STEEL PROCESSING AND ELECTRONIC INDUSTRY WASTE TYPES AND QUANTITIES

Bac Kan

The industrial hazardous waste (HW) generation in Bac Kan Province is rather limited (51 tonne/year) and the majority of the HW is generated by the healthcare sector. The healthcare facilities in Bac Kan Province generate in average of 2.3 tonne/year/healthcare facility, whereas the other industries generate 80 kg HW/year/enterprise.

TABLE 3-1 **The annual HW quantity divided into different sectors in Bac Kan Province**

Category of enterprises	Number of enterprises	Total quantity of HW (tonne/year)
Mine exploration & processing industry	27	2.1
Healthcare facilities	20	46
Others (automobile repairing, gasoline & oil trading, paper & woodworks manufacture	43	3.2
Total	90	51

Source: Annual waste management report prepared by DONRE (2016)

Based on the waste management reports prepared by 20 selected mining industries in Bac Kan Province, the industrial waste has been divided into the categories presented in Table 3-2 below. The division of the hazardous waste is based on the Vietnamese HW classification[43] and the division of the non-hazardous waste is based on the information provided in the waste management reports prepared by the mining enterprises in Bac Kan Province.

The HW quantities reported in Table 3-2 do not correspond to the HW quantities from the mining industry presented in the Table 3-1; therefore, the price type and quantities of HW would need further investigation. During the site visits to the lead-zinc exploration enterprises in Bac Kan province, it was observed that there have been discussions between MONRE and one of the metal exploring enterprises on whether the paste from the floating process was to be classified as hazardous or non-hazardous waste. This could be the reason why the paste is classified as hazardous waste in the enterprise's annual report and not in the DONRE annual waste report.

The waste management reports prepared by the mining enterprises in Bac Kan Province reveal that the major HW type is "Waste from physical and chemical processing of non-metallic ferrous minerals" and this HW type constitutes almost 100% of the HW from the mining industry. The other HW streams consists of 19 different HW types. In addition to the HW types generated by the mining industry in Bac Kan, the mining industry also generates non-hazardous waste: Sludge as well as soil and gravel waste.

TABLE 3-2 **The annual quantities of hazardous and non-hazardous waste from the mining sector in Bac Kan Province**

Hazardous / Non-Hazardous waste	Type of waste	Annual quantity (tonne/year)
Hazardous	Waste containing dangerous substances from physical and chemical processing of non-metalliferous minerals (01 02 01)[44]	4,700
	Different HW types (19 different HW codes)	3
Non-Hazardous	Sludge	2,000
	Soil & gravel waste	1,140

The figures in bracket are the Vietnamese hazardous waste codes. Source: Waste management reports prepared by five mining enterprises (2016) in Bac Kan Province. Reports provided by DONRE Bac Kan

43 Circular No. 36/2015/TT-BTNMT: Management of hazardous waste, Appendix 1: List of hazardous wastes.
44 Paste resulting from floating process - temporary storage

Thai Nguyen

The industrial HW generation in Thai Nguyen Province is relatively high - almost 300,000 tonne/year, see Table 3-3. Other industrial waste types generated in the province include waste from black metal mining (9 mln tonne/year) and waste from colour metal mining (5 mln tonne/year).

Based on the waste management reports prepared by 20 selected industrial facilities[45] in Thai Nguyen Province, the industrial waste has been divided into the categories presented in Table 3-4 below. The division of the hazardous waste is based on the Vietnamese HW classification[43] and the division of the non-hazardous waste is based on the information provided in the waste management reports prepared by the enterprises in Thai Nguyen.

The quantities presented in Table 3-4 are considerably lower than then presented in other reports and likely only selected waste management reports have been provided.

TABLE 3-3 **Annual hazardous and non-hazardous waste quantities in Thai Nguyen Province divided into different waste types**

Category of enterprises	Number of enterprises	Total quantity of waste tonne/year
Non-hazardous industrial waste	2,500	504,000
Hazardous industrial waste		270,000
Non-hazardous waste from steel industries	>50	130,000
HW from steel industries		18,000
Waste from black metal mine (sludge, soil & sand)	50	9,000,000
Waste from colour metal mine (sludge, soil & sand)	7	5,000,000

Source: Data from DONRE Thai Nguyen (2016)

45 The 20 selected enterprises include: one enterprise from the electronic industry, nine from the mining inustry and 11 from the steel producing industry

TABLE 3-4 **Annual quantities of hazardous and non-hazardous waste reported by enterprises in industrial sectors: mining (9), steel producing (5) and electronic (1) in Thai Nguyen**

Type of industry	Hazardous waste/ Non-hazardous waste	Type of waste	Annual quantity of waste (tonne/year)
Mining sector	Hazardous	Brake fluids (other than those mentioned in heading 17) (15 01 07)	20
		Oil filters (15 01 02)	10
		Synthetic engine, gear and lubricating oils (17 02 03)	56
		Other HW types (15 different HW codes)	35
	Non-hazardous	Soil & sand waste	1,439,147
		Lime kiln slag	200
Steel producing sector	Hazardous	Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances (18 02 01)	166
		Sludges and filter cakes from gas treatment containing dangerous substances (05 01 03)	2,410
		Solid wastes from gas treatment containing dangerous substances in plants using steel ore as materials (05 01 01)	3,600
		Other HW types (14 different HW codes)	0.02
	Non-hazardous	Iron scrap	850
		Kiln dismantling material	275
		Kiln slag	50,495
		Settlement sludge	35,000
Electronic sector	Hazardous	Hard packaging including empty pressure containers (18 01 02)	24
		Other organic solvents, washing liquids and mother liquors (03 01 03)	46
		Waste paint and varnish containing organic solvents or other dangerous substances (08 01 01)	26
		Other HW types (9 different HW codes)	19

Source: Waste management reports prepared by enterprises report (2016); provided by DONRE Thai Nguyen. The figures in bracket are the Vietnamese hazardous waste codes.

The data in Table 3.4 above reveals that the major industrial waste quantities are generated in the mining sector and includes the soil and sand waste (almost 1.5 mln tonne/year). The HW generation from the mining industry is rather limited and includes different oil containing waste from the use of machinery.

The steel producing industry also generated more non-hazardous waste than HW. The major non-hazardous waste types include: Kiln slag (50,495 tonne/year) and settlement sludge (35,000 tonne/year). The HW types include sludges, filter cakes and solid waste from gas treatment.

The electronic sector in Thai Nguyen Province generates rather limited quantities of HW and these include mainly waste solvents and paints (72 tonne/year). The HW reported for the electronic sector in Thai Nguyen Province is generated by one single enterprise.

It is obvious, that the 20 waste management reports that were disclosed do not provide a full picture of the overall industrial waste management situation in Thai Nguyen. The disclosed reports and the visits organised provide details of the major environmental concerns of DONRE Thai Nguyen.

3.2.2 SUITABLE OPTIONS FOR MINIMISATION, RECYCLING, TREATMENT AND DISPOSAL FOR MINING WASTE, STEEL PROCESSING AND ELECTRONIC INDUSTRY

EU best available techniques reference document (BREF) related to waste management

The European Integrated Pollution Prevention and Control Bureau (EIPPCB) was set up in 1997 to organise an exchange of information between EU Member States, industry and non-governmental organisations promoting environmental protection on Best Available Techniques (BAT), associated monitoring and developments in them.

With the entry into force of the Industrial Emissions Directive (IED, 2010/75/EU), the EIPPCB organises and coordinates the exchange of information that leads to the drawing up and review of BAT reference documents according to the dispositions of the Guidance document on the exchange of information (Commission Implementing Decision 2012/119/EU).

The European IPPC Bureau is an output-oriented team which produces Best Available Techniques Reference Documents, called BREFs. BREFs are the main reference documents used by competent authorities in Member States when issuing operating permits for the industrial installations that represent a significant pollution potential in Europe. There are about 50,000 of these installations in Europe including waste treatment facilities. The BREF document covering waste treatment industries[46] (hazardous waste and non-hazardous waste) was adopted in August 2006.

Waste from mining industry

Waste from extractive operations (i.e. waste from extraction and processing of mineral resources) is one of the largest waste streams. It involves materials that must be removed to gain access to the mineral resource, such as topsoil, overburden and waste rock, as well as tailings remaining after minerals have been largely extracted from the ore.

Some of these wastes are inert and hence not likely to represent a significant pollutant threat to the environment, and possible collapse if stored in large quantities. However, other fractions, in particular those generated by the non-ferrous metal mining industry, may contain large quantities of dangerous substances, such as heavy metals. Through the extraction and subsequent mineral processing, metals and metal compounds tend to become chemically more available, which can result in the generation of acid or alkaline drainage.

Suitable options for treatment and disposal of waste from the mining sector are presented in Table 3-5.

46 Reference Document on Best Available Techniques for Waste Treatment Industries, European Commission, August 2006. http://eippcb.jrc.ec.europa.eu/reference/BREF/wt_bref_0806.pdf

TABLE 3-5 **Suitable options for treatment and disposal of waste from mining sector including typical costs**

Waste type	Suitable options for treatment and disposal of mining waste	Description	Typical treatment costs (VND/kg)
Paste from Pb and Zn extraction	Backfilling / cemented backfilling	The remaining from the extraction of the lead and zinc from the ore material (Bac Kan Province) may be used as back filling material, either with or without prior mixing with cement.	1,100-2,250
Overburden (soil and rock that is removed to gain access to the ore deposits at open pit mines.)	Landscape contouring and revegetation during mine closure.	It is usually piled on the surface at mine sites where it will not impede further expansion of the mining operation – moving large volumes of material is expensive. Overburden generally has a low potential for environmental contamination	1,100-2,250
Paste from Pb and Zn extraction	Backfilling / cemented backfilling	The remaining from the extraction of the lead and zinc from the ore material (Bac Kan Province) may be used as back filling material, either with or without prior mixing with cement.	1,100-2,250
Overburden (soil and rock that is removed to gain access to the ore deposits at open pit mines.)	Landscape contouring and revegetation during mine closure.	It is usually piled on the surface at mine sites where it will not impede further expansion of the mining operation – moving large volumes of material is expensive. Overburden generally has a low potential for environmental contamination	1,100-2,250
Waste rock (material that contains minerals in concentrations considered too low to be extracted at a profit)	Waste rock dumps are generally covered with soil and revegetated following mine closure, Re-mining when increase in mineral market prices or improvements in extraction technology.	Waste rock is often stored in heaps or dumps on the mine site, but may be stored underwater with tailings if it contains a lot of sulphide minerals and has a high potential for acid rock drainage formation.	1,100-2,250
Tailings (finely ground rock and mineral waste products of mineral processing operations, e.g. (sand, silt, and clay-sized material)	Backfilling in underground mines Storage in open pits Pumped into tailing ponds on site	Tailings can also contain leftover processing chemicals, and are usually deposited in the form of a water-based slurry into tailings ponds (sedimentation lagoons enclosed by dams built to capture and store the tailings).	1,100-2,250
Water treatment sludge (produced at active water treatment plants used at some mine sites, and consists of the solids that had been removed from the water as well as any chemicals that had been added to improve the efficiency of the process)	Landfilling	The majority of sludge has little economic value and is handled as waste.	840-2,800

Source: EU BREF note on mining activities[47] and waste treatment[48] and Miningfacts.org

47 Reference Document on Best Available Techniques for Management of Tailing and Waste-Rock in Mining Activities, European Commission, January 2009. http://eippcb.jrc.ec.europa.eu/reference/BREF/mmr_adopted_0109.pdf

48 Reference Document on Best Available Techniques for Waste Treatment Industries, European Commission, August 2006. http://eippcb.jrc.ec.europa.eu/reference/BREF/wt_bref_0806.pdf

TABLE 3-6 **Statistical data for enterprises categorised as "Mining of metal ores"**

	2010	2012	2013	2014	2015
No of acting enterprises	202	346	328	306	273
No of employees	16,112	21,458	20,972	17,952	15,010
Average capital of enterprises, billion VND	12,731	26,577	35,532	40,380	49,078
Value of fixed asset and long-term investment, billion VND	9,502	16,883	23,961	24,496	33,022
Net turnover, billion VND	5,169	11,075	12,097	10,978	9,218

Source: Vietnam General Statistics Office, Business Result of Vietnamese Enterprises in the period 2010-2015

Table 3-5 reveals that the majority of the suitable waste treatment technologies for mining waste are rather low-tech technologies, as they include backfilling and landscape contouring. Table 3-6 below presents statistical data regarding the development of enterprises categorised as "Mining of metal ores" in the national Vietnamese statistics. The data shows that the number of employees in the mining industry has decreased 6% during 2010-2015 and the turnover has increased by 78% during the same period.

The site visits to the mining industries in the two provinces (Bac Kan and Thai Nguyen) revealed that the mining enterprises were responsible themselves for treatment and disposal of the residues (waste) from the mining activities, i.e. paste from Pb and Zn extraction, tailings and sludges. One single mining enterprise in Bac Kan province has established a small "landfill" with liner for long term storage of the pastes.

The study's assessment is that there is an immediately need for disposal options for residues generated by the mining activities, at they constitute enormous quantities. As there is a limited quantity of HW in Bac Kan Province, it would not be economic feasible for to establish a HW treatment facility serving the industrial facilities in Bac Kan only.

Waste from steel processing industry

This sub-section presents suitable options for treatment and disposal of the major waste types (hazardous and non-hazardous) from the steel producing industry.

TABLE 3-7 Suitable options for treatment and disposal of waste from steel processing industry

Waste type	Suitable options for treatment and disposal of mining waste	Description	Typical treatment costs (VND/tonne)
Fly ashes	Backfilling in underground mines	The fly ashes are disposed in underground mines to stabilise the decommissioned areas of mines	1,100-2,250
Kiln slag	Backfilling Road construction	The kiln slag may be used for road construction or back filling dependent on the concentration of heavy metals and salts in the slag	1,100-2,250
Iron scrap	Material recovery/usage by cement plant	The iron scrap from the steel production may have sufficiently high content of ferrous for material recovery/usage in the cement industry as the cement industry is in the need of ferrous for the cement production.	Price is dependent on negotiation with cement plant
Sludges and filter cakes from gas treatment containing dangerous substances	Landfilling Backfilling in underground mines	The majority of sludge has little economic value and is handled as waste.	3,500 1,100-2,200
Solid wastes from gas treatment containing dangerous substances in plants using steel ore as materials	Landfilling Backfilling in underground mines	The fly ashes are disposed in underground mines to stabilise the decommissioned areas of mines	3,500 1,100-2,200

Source: Based on EU BREF note[46]

Table 3.7 reveals that the suitable recovery, treatment and disposal options includes material recovery, backfilling and landfilling. At present, material recovery of iron scrap takes place, as iron scrap is sold to the cement industries. Table 3.8 presents statistical data regarding the development of enterprises categorised as "Manufacture of basic metals" in the national Vietnamese statistics. The data shows that the number of employees in the metal producing industry has increased by 26% from 2010 2015 and the turnover has increased by 45% during the same period.

The site visits at the steel producing facility in Thai Nguyen revealed that no treatment facility currently exists for solid HW and non-hazardous waste from the steel producing industry apart from the recovery of the iron slag. The potential treatment and disposal options identified were landfilling, underground waste disposal/ backfilling and road construction. There is an immediately need for treatment and disposal options for the above-mentioned waste types from the steel producing industry.

Waste from electronic industry

The electronic producing industries in Thai Nguyen Province generates a wide variety of hazardous waste types. The suitable options for treatment and disposal of hazardous waste from the electronic industry is described in the section on “suitable option for treatment of disposal of industrial waste, Binh Thuan”. At present four HW treatment facilities exist in Thai Nguyen, which serve both the industrial facilities in Thai Nguyen and Bac Kan Provinces. One facility in particular serves one of the enterprises in the electronic industry. The HW incineration capacity is rather limited: 2,500 kg/ hour equal to 19,000 tonne/year.

During the sit visit to Thai Nguyen, two of the hazardous waste incinerators operating

TABLE 3-8 **Statistical data for enterprises categorised as "Manufacture of basic metals"**

	2010	2012	2013	2014	2015
No of acting enterprises	858	1,034	1,067	1,056	1,079
No of employees	71,779	72,711	77,214	81,725	83,675
Average capital of enterprises, billion VND	133,493	175,917	237,768	338,765	451,129
Value of fixed asset and long-term investment, billion VND	61,143	91,340	139,183	247,534	353,053
Net turnover, billion VND	185,260	209,829	215,432	248,068	269,841

Source: Vietnam General Statistics Office, Business Result of Vietnamese Enterprises in the period 2010-2015.

in Thai Nguyen Province were visited. The HW incinerators are equipped with flue gas treatment and the flue gas is measured on a quarterly basis. The flue gas treatment systems at the two facilities included:

1. Cooling and bag filters.
2. Cooling, cyclone and charcoal absorption

The study assesses that the flue gas treatment systems at the hazardous waste treatment facilities that were visited in Thai Nguyen, as well as those visited in Hanoi, do not meet international standards for removal of dust, CO, HCl, sulphur oxides, NO_X, dioxin etc. As the flue gas emission are not in compliance with international standards, the flue gas emissions may cause environmental pollution. In addition, it appears that the flue gas treatment residues are not disposed of at a hazardous waste landfill.

Table 3-9 presents statistical data regarding the development of enterprises categorised as "Manufacture of computer, electronics and optical products". The data shows that the number of employees in the electronic industry has tripled during 2010-2015 and the turnover in 2015 has escalated to ten times the level of 2010.

The HW generated by the electronic sector might be treated and disposed of by the present HW treatment facilities operating in Thai Nguyen Province, as the present HW quantities are rather limited and of a nature which can be adequately and properly handled by the present treatment facilities.

TABLE 3-9 **Statistical data for enterprises categorised as "Manufacture of computer, electronic and optical products"**

	2010	2012	2013	2014	2015
No of acting enterprises	613	739	839	1021	1,145
No of employees	167,562	289,757	327,659	410,994	497,037
Average capital of enterprises, billion VND	78,818	179,389	247,649	369,040	511,199
Value of fixed asset and long-term investment, billion VND	41,054	87,799	113,500	178,194	258,633
Net turnover, billion VND	125,184	475,606	777,415	915,267	1,268,354

Source: Vietnam General Statistics Office, Business Result of Vietnamese Enterprises in the period 2010-2015.

3.3 WASTEWATER SLUDGE IN VIETNAM

3.3.1 WASTEWATER SLUDGE QUANTITIES AND DISTRIBUTION

The wastewater treatment facilities serving households in Vietnam have been registered including the treatment technology applied. Substantial data has been obtained from a former WB study[49].

Types of wastewater treatment technologies applied and number of wastewater treatment facilities where different technologies are applied in different parts of Vietnam are presented Table 3-10.

Table 3-10 illustrates that the most frequently applied technology is the sequencing batch reactor which is used in almost 30% of the wastewater treatment facilities. The second most frequent technology applied is the conventional activated sludge treatment technology and the oxidation ditch, which are both applied at 20% of the wastewater treatment facilities.

The quantity of the wastewater sludge generated has been estimated based on the design capacity of the wastewater treatment plant and experience of wastewater sludge generation from similar conditions. The estimated wastewater sludge quantity has been compared with wastewater sludge generation from a JICA study[50] and the quantities are found to be almost equal.

The total number of wastewater treatment facilities in the different provinces of Vietnam and the estimated wastewater sludge generation is presented in the Table 3-11 below. The total number of household wastewater treatment facilities in Vietnam is 50 and the quantity is divided regionally with 18 in Northern Vietnam, 15 in Central Vietnam and 17 in Southern Vietnam. The wastewater sludge generation in Ho Chi Minh accounts for almost 43% of the total national wastewater sludge generation. The percentages of wastewater sludge generation in the three regions of Vietnam are presented below:

- North: 36 %

TABLE 3-10 **Types of wastewater technologies applied and their presence in different regions of Vietnam**

Type of treatment technology	Part of Vietnam			
	North	Central	South	Total
Activated sludge A2O	3		2	5
Aeration ponds		1		2
Aerobic ponds			1	1
Biological ponds		2	1	2
Conventional activated sludge	5	2	3	10
Covered anaerobic ponds		4		4
Imhoff + trickling filters			1	1
Oxidation ditch	2	3	5	10
Sequencing batch reactor	8	2	4	14
Trickling filter		1		1
Total	18	15	17	50

Source: Vietnam Urban Wastewater Review, World Bank, December 2013

49 Vietnam Urban Wastewater Review, World Bank, December 2013
50 Preparatory study on construction project for Yen Xa wastewater treatment plant PPP infrastructure project study, Final report, prepared for Japan International Cooperation Agency, March 2013.

- Central: 13 %
- South: 51 %

Table 3-11 illustrates that most of the provinces have only one wastewater treatment facility except for the larger cities such as Hanoi (North), Da Nang (Central) and Ho Chi Minh (South). These cities have 8, 6 and 6 wastewater treatment facilities, respectively.

TABLE 3-11 **The number of wastewater treatment plants in different provinces of Vietnam and the estimated wastewater sludge generation (m^3/year) with dry matter of 15%**

Part of Vietnam/Province	No. of household wastewater treatment facilities	Wastewater sludge generation (m^3/year)
Central	**15**	**43,601**
Binh Dinh	2	3,517
Danang	6	25,639
Hoi An	1	1,119
Hue	1	2,734
Nghe An	2	5,196
Ninh Thuan	1	1,599
Quang Binh	1	1,399
Thanh Hoa	1	2,398
Northern	**18**	**123,548**
Bac Giang	1	1,599
Bac Ninh	2	5,995
Ha Nam	1	799
Hai Duong	1	2,158
Hai Phong	1	5,755
Hanoi	8	103,084
Quang Ninh	2	1,759
Thai Nguyen	1	1,599
Vinh Phuc	1	799
Southern	**17**	**178,396**
An Giang	1	320
Ba Ria - Vung Tau	2	5,116
Binh Duong	2	5,539
Buon Ma Thuot	1	1,299
Can Tho	1	4,796
Da Lat, Lam Dong	1	1,183
Ho Chi Minh	6	148,040
Nha Trang	1	6,395
Soc Trang	1	2,809
Tra Vinh	1	2,899
Total	**50**	**345,544**

3.3.2 SUITABLE OPTIONS FOR DISPOSAL AND TREATMENT OF WASTEWATER SLUDGE

The suitable options for treatment and disposal of wastewater sludge are presented in Table 3-12 below.

TABLE 3-12 Suitable options for treatment and disposal of wastewater sludge

Suitable options for treatment and disposal of wastewater sludge	Description	Typical treatment costs (VND/tonne)
Co-incineration in cement kilns	Traditional kiln fuels are gas, oil and coal. Materials like dried wastewater sludge is an alternative fuel for the cement industry. Dried wastewater sludge has proven to have a satisfactory calorific value for the cement industry as specified for alternative fuels[51]. The utilisation of wastewater sludge has as an alternative fuel and its effect has been analysed covering all process, health, safety and environmental standard[52].	Price is dependent on negotiation with cement industry and will depend on annual quantity
Co-incineration in power plants	Large volumes of dried sewage sludge with calorific values between 3 and <10 MJ/kg are used in power plants.	-
Composting	Sewage sludge can be transformed into composting by windrow composting maintained at 40°C for at least 5 days and for 4 hours during this period at a minimum of 55°C within the body of the pile followed by a period of maturation adequate to ensure that the compost reaction is substantially complete[53].	700-2,800
Biogas production	Anaerobic digestion is used in industry to handle very high COD wastes and as a treatment process for wastewater sludge after an aerobic treatment of the wastewaters. The production of biogas from controlled anaerobic digestion is one of the principal advantages of the process. Anaerobic digestion involves the bacterial decomposition of organic material in the (relative) absence of oxygen. One of the main limits on the anaerobic digestion process is its inability to degrade lignin (a major component of wood). This is in contrast with the process of aerobic biodegradation.	1,000-2,800
Soil improvement	Wastewater sludge may be used as soil improvement to improve the quality of the soil, e.g. sandy soils with addition of coal and wastewater sludge.	-

Source: References are provided for each specific treatment options. Typical treatment costs are based on general experience and BREF document on waste treatment[46]

51 Wzorek, M. Characterisation of the properties of alternative fuels containing sewage sludge. Fuel processing technology, 2012:104, 80-89.
52 Zabaniotou, A., & Theofilou, C.. Green energy at cement kiln in Cyprus—Use of sewage sludge as a conventional fuel substitute. Renewable and Sustainable Energy Reviews, 2008;12(2), 531-541.
53 Wastewater treatment and use in agriculture - FAO irrigation and drainage paper 47, FAO, 1992

3.3.3 REGIONAL MANAGEMENT PLANS AND TREATMENT SCHEMES FOR WASTEWATER SLUDGE IN NORTHERN VIETNAM

The largest quantity of wastewater sludge in Northern Vietnam is generated in Hanoi Province. The majority of the wastewater sludge is generated at the two wastewater treatment plants Yen So and Yen Xa and these two wastewater treatment plants generate approximately 75,000 tonnes/year of wastewater sludge[54]. The sludge generation is based on the design capacity and it might be smaller, if the wastewater plant is running at a capacity lower than the design capacity.

Co-incineration of the wastewater sludge from these two wastewater treatment facilities is a possibility, as a newly established cement plant is located in Ninh Binh, 100 km south of Hanoi. The wastewater sludge quantity is sufficient to make this option attractive for the cement plant. There could be other cement plants interested in the dried sewage sludge and a separate report about cement co-incineration possibilities has been prepared and will be presented in September 2018.

The remaining wastewater facilities in the Northern part of Vietnam generate relatively small quantities of wastewater sludge on annual basis ranging from 700 – 6,000 tonne/year for each plant. If collection, treatment and disposal schemes have to be established for the smaller wastewater treatment facilities, it could be used as a supplement at the composting facilities for domestic solid waste.

3.3.4 POTENTIAL FOR CO-INCINERATION IN SOUTHERN VIETNAM

The largest quantities of wastewater sludge in Southern Vietnam are generated in Ho Chi Minh Province. The majority of the wastewater sludge is generated at the three wastewater treatment plants: Nhieu Loc - Thi Nghe, Tham Luong - Ben Cat and Binh Hung. The three wastewater treatment plants generate approximately 139,250 tonne/year of wastewater sludge[54]. The sludge generation is based on the design capacity and it might be smaller, if the wastewater plant is running at a capacity lower than the design capacity.

Co-incineration of the wastewater sludge from these three wastewater treatment facilities is a possibility at the cement plants operating in Ho Chi Minh Province. The wastewater sludge quantity is sufficient to make this an attractive option for the cement plants.

3.4 INDUSTRIAL (HAZARDOUS) WASTE FOR LARGE INDUSTRIES – BINH THUAN

3.4.1 LARGE INDUSTRIES (HAZARDOUS) WASTE TYPES AND QUANTITIES

Industrial hazardous waste

The annual HW generation in Binh Thuan province is almost 1,000 ton, see Table 3-13. The majority of the HW is generated by the oil and gas industry (550 tonne/year) whereas the energy sector generates the second largest quantity (210 tonne/year). The HW generation from the healthcare sector accounts for 16% of the annual HW generation in the Binh Thuan province (158 tonne/year).

54 Dry matter content of 15%

TABLE 3-13 **The annual industry HW quantity divided into different sectors in Binh Thuan**

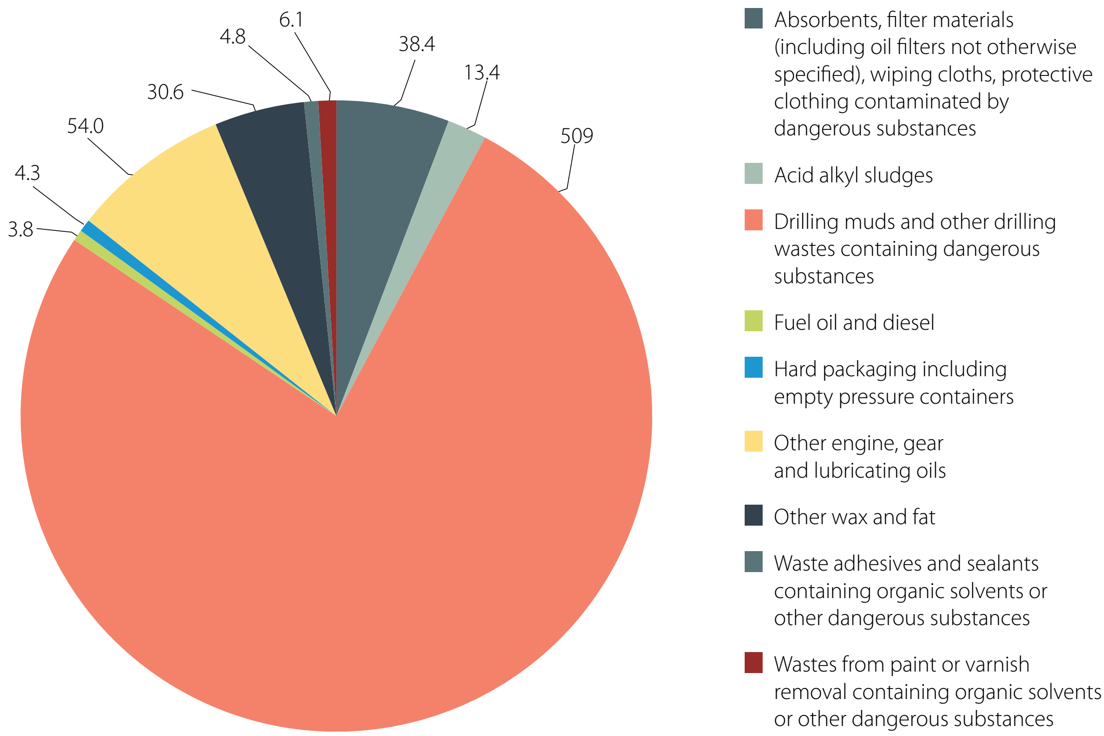
Category of enterprises	Number of enterprises	Total quantity of industrial HW
Industries	30	18.6
Petroleum, oil and gas	12	551
Tourism	60	2.5
Food production	11	6.0
Aqua cultural and fishery processing	13	0.9
Mineral and natural resources	17	3.3
Agricultural / farmers	11	0.55
Healthcare facilities	12	158
Energy	10	210
Services and others	12	29.4
Total	188	979

Source: Annual waste management report prepared by DONRE Binh Thuan (2016).

Based on waste management reports submitted by 13 enterprises to Binh Thuan DONRE, the industrial waste generation has been divided into the categories presented in Figure 3-1 and Table 3-14. The division of the hazardous waste is based on the Vietnamese HW classification and the division of the non-hazardous waste is based on the information provided in the waste management reports prepared by the enterprises in Binh Thuan. The waste management reports account for 700 tonne/year (2016) of the industrial HW, equal to 90% of the industrial HW reported in Table 3-13 above, despite the data being sources from only 13 of 188 enterprises' reports.

Table 3-14 illustrates, that the majority of the waste (509 tonne/year) is "Drilling muds and other drilling wastes containing dangerous substances". The waste is generated by the oil and gas industry and co-incinerated at one of the Holcim cement plants. The second and third largest quantities are "Other engine, gear and lubricant oils" (54 tonne/year) and "Absorbents, filter materials, wiping cloths, protective clothing contaminated by dangerous substances" (38.4 tonne/year).

The industrial enterprises visited in Binh Thuan Province (see Annex 4) reported that the enterprises have entered into service agreements related to the collection and treatment of the HW generated. There are no dedicated Hazardous Waste treatment facilities in Binh Thuan Province, therefore the HW is collected and transported to neighbouring provinces for treatment.



Source: Waste report prepared by industrial facilities and submitted to DONRE Binh Thuan, 2016

FIGURE 3-1 **Industrial HW types reported by the industrial facilities in Binh Thuan province in 2016**

TABLE 3-14 **The annual quantities of HW from industrial sector in Binh Thuan.**

Industrial HW categories	Annual waste generation in 2016 (tonne/year)
Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances (18 02 01)	38.4
Acid alkyl sludges (01 04 03)	13.4
Drilling muds and other drilling wastes containing dangerous substances (01 03 02)	509
Fuel oil and diesel (17 06 01)	3.8
Hard packaging including empty pressure containers (18 01 02)	4.3
Other engine, gear and lubricating oils (17 02 04)	54.0
Other wax and fat (17 07 04)	30.6
Soft packaging (18 01 01)	13.8
Waste adhesives and sealants containing organic solvents or other dangerous substances (08 03 01)	4.8
Wastes from paint or varnish removal containing organic solvents or other dangerous substances (08 01 03)	6.1
Wastes not otherwise specified (17 07 03)	3.9
Different hazardous wastes (16 different waste categories)	17.3
Total	699.4

Source: Waste management report prepared by enterprises (2016). Reports provided by DONRE Binh Thuan. Figures in brackets are the Vietnamese hazardous waste codes.

Waste from thermal power plants

The largest industrial waste producer in Binh Thuan Province is the Vinh Than Power Station plants (thermal power plants), which consist of the following units:

- Unit 1 – Energy production capacity with two units with a capacity of 1,240 MW (trial operation).
- Unit 2 - Energy production capacity with two units with the capacity of 1,244 MW – in operation.
- Unit 3 - Energy production capacity with three units with a capacity of 1,980 MW.
- Unit 4 - Energy production capacity with two units with the capacity of 1,200 MW - in operation and extended Unit 4 with one unit with capacity of 600 MW (under construction)

At present the power plant generates 1,200,000 tonnes of non-hazardous ashes annually from the energy production. The thermal power plant uses Vietnamese coal for the production of energy and this is the reason for the high waste generation[55]. According to the design, once the plants in Vinh Tan Power Center begin operation, the amount of ash and slag generated is about 3,800,000 tons/year. At present, the ashes (dry) are disposed of at the slag storage area/landfill next to the thermal power plant. The landfill is operated by the thermal power plant. A small-scale pilot production enterprise Mãi Xanh (private company) has been established for the production of bricks from the ashes, and the enterprise has a capacity of 4,500 tonne/day with two (2) production lines.

3.4.2 SUITABLE OPTIONS FOR MINIMISATION, RECYCLING, TREATMENT AND DISPOSAL OF (HAZARDOUS) WASTE FROM LARGE INDUSTRIES IN BINH THUAN

Industrial hazardous waste

As described earlier, the majority of the HW generated by the large industries in the Binh Thuan Province is drilling mud and other HW suitable for incineration. The different treatment options for the different HW categories identified in Binh Thuan Province are presented in the Table 3-15.

55 The waste generation from local coal is 37-40% of the input, whereas the waste generation from the use of Indonesian coal is 6-8% of the input.

TABLE 3-15 **Suitable options for recycling, treatment and disposal for different HW types identified in the Binh Thuan Province**

Industrial HW type	Suitable options for minimisation, recycling, treatment and disposal	Typical treatment costs (VND/tonne)
Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	Incineration at dedicated HW treatment facility	16,600
Acid alkyl sludges	Incineration at dedicated HW treatment facility	16,600
Drilling muds and other drilling wastes containing dangerous substances	Thermal absorption and recovery of oil Co-incineration in cement plant Incineration at dedicated HW treatment facility	- - 19,300
Fuel oil and diesel	Co-incineration in cement plant Incineration at dedicated HW treatment facility	- 2,700
Hard packaging including empty pressure containers	Pressure container: Reuse or recovery of metal Incineration at dedicated HW treatment facility (metal drums)	0 13,600
Other engine, gear and lubricating oils	Recovery of base oil Co-incineration in cement plant Incineration at dedicated HW treatment facility	8,400-9,300 Dependent on quantity 1,100-16,000
Other wax and fat	Incineration at dedicated HW treatment facility	16,000
Soft packaging	Incineration at dedicated HW treatment facility	13,600
Waste adhesives and sealants containing organic solvents or other dangerous substances	Incineration at dedicated HW treatment facility	13,600
Wastes from paint or varnish removal containing organic solvents or other dangerous substances	Incineration at dedicated HW treatment facility	13,600

Source: Experience and EU BREF note on waste treatment[46]

At present the annual HW generation in Binh Thuan is rather limited and the annual quantity produced does not justify the establishment of a HW treatment facility in Binh Thuan Province. The major HW quantity is drilling mud, generated by the oil and gas industry, and this HW type is treated by the cement industry. Thermal absorption and recovery of the oil from the drilling mud has proven to be economic feasible in several other oil-producing countries, e.g. Nigeria and Angola.

During the site visits, several of the industrial facilities explained that the service provider for collection and treatment of their hazardous waste was located in the neighbouring provinces, which sometimes created challenges, as waste collection needs to be planned well in advance. All HW generators are obliged to enter into a written agreement with a service provider for the collection, transport and treatment/disposal of the HW generated prior to operating the industrial facility. The option of establishing a provincial intermediate storage facility serving several industrial facilities could be explored, if the current regulatory system allows such possibility.

Waste from thermal power plants

The majority of the non-hazardous waste in Binh Thuan Province is comprised of fly ashes from the thermal power plant. The different treatment options for fly ashes are presented in Table 3-16.

TABLE 3-16 **Suitable options for treatment and disposal for fly ashes from thermal power plants in Binh Thuan Province**

Industrial non-hazardous waste type	Suitable options for minimisation, recycling, treatment and disposal	Typical treatment costs (VND/tonne)
Fly ashes from thermal power plant	Solidification and stabilisation by cement	700
	Backfilling in underground mines (stabilisation of decommissioned areas of mines)	1,100-2,250
	Disposal in underground mines	2,800
	Solidification and stabilisation by other components (bitumen or clay minerals)	700
	Landfilling (EU)	3,500
	Solidification, stabilisation and production of bricks (current used method)	-
	Landfilling of dry ashes (current used method)	-

Source: Experience and EU BREF note on waste treatment[46]

At present two (2) of four (4) thermal power plants are in operation in Binh Thuan Province. When the two new plants are in operation, non-hazardous waste generation is expected to increase considerably. The future waste quantities will very much depend on the origin of the coal to be used in the future thermal power plants.

As the waste quantities are enormous, it is assessed that an in-depth analysis should be carried out to determine the economically feasible recovery and treatment options for the fly ashes from the energy production.

3.5 INDUSTRIAL (HAZARDOUS) WASTE MANAGEMENT, TREATMENT, FINANCING AND CHALLENGES

This section presents the findings regarding the current and future waste treatment and disposal demands for the investigated waste streams (mining waste, wastewater sludge and industrial waste). It also provides an overview of suitable management and operational structures for industrial (hazardous) waste, private involvement, financing of treatment, the required legislation, monitoring and enforcement and key challenges and recommendations.

3.5.1 CURRENT AND FUTURE TREATMENT OPTIONS IN VIETNAM

MONRE has provided data regarding the current HW treatment facilities in Vietnam. The data on all hazardous waste treatment facilities in Vietnam was kept in an Excel file, which made it difficult to identify the treatment capacity in each province, the type of treatment facility available and the capacity of the treatment facilities, which have obtained permission.

The HW treatment facilities which have obtained operating permits in the three analysed provinces are listed in Table 3-17, which shows that no licensed HW treatment facilities exist in the Bac Kan and Binh Thuan Provinces. The industrial enterprises in Bac Kan and Binh Thuan have entered service agreements with service providers (HW collection and treatment) in the neighbouring provinces.

The overall picture of the HW treatment facilities in Vietnam, is that the HW treatment facilities are relatively small in design/permit capacity. The majority of the incineration facilities have a capacity of 1,000 kg/hour, equivalent to 7,500 tonne/year. In Europe a HW incineration kiln would be in the size range of 40,000 – 60,000 tonne/year and serve a larger number of enterprises, across several regions.

Regarding the hazardous wastes, and in particular the non-hazardous waste types, generated by the mining, the steel producing and the energy producing industries in Vietnam, it is recommended to investigate the possibilities for new waste treatment options, e.g. fly ashes from the power plants and steel producing enterprises, paste from lead and zinc extraction.

TABLE 3-17 **Type of HW treatment facilities in the three analysed provinces and the permit capacity of the different facilities**

Province	Name of company	Type of facilities	Permit capacity kg/hour	Permit capacity (tonne/day)	Total annual permit quantity (tonne/year)
Thai Nguyen	Welfare Trade and Services Cooperative	Refinery and Oil Recovery	1,000		
		Oil distillation system	2,300		
		HW incinerator	500		
		Solidification system	1,000		
		Drum cleaner system	-	-	
		Fluorescent lamp processing system	10		
		Preliminary equipment Battery	500		
		Electronic waste processing equipment	300		
		Metal detergent adhesive detergent	500		
	Viet Bac Colouring Metal Joint Stock Company	Rotary kiln	15,000		30,000
	Viet Xuan New Environment Joint Stock Company	HW incinerator	1,000		44,800
		Waste oil recycling system		5	
		Waste water and wastewater treatment system		100	
		System of recovery and processing of electrical and electronic equipment		10	
		Aluminium, zinc recycling system		10	
		Reclaimed metal from mud waste		4	
		Fluorescent lamp processing system		0.5	
		Battery breaking system		8	
		Drum cleaner system		5	
		System of cleaning packaged, hazardous metal particles		10	
	Anh Dang Environmental Services Company Limited	HW incinerator, capacity	1,000		38,000
		Waste oil recycling system	625		
		System of recovery and processing of electrical and electronic equipment	625		
		Fluorescent lamp processing system	25		
		Demolition system, waste battery treatment	500		
		System of cleaning of packaging, metal oil and chemicals	2,500		

Source: Data obtained from MONRE

3.5.2 MANAGEMENT AND OPERATIONAL STRUCTURE

According to Vietnamese legislation, all industrial facilities are required to enter into an agreement with a service provider regarding the collection, transport and treatment/ disposal of the HW generated by the industrial facilities. The HW must be collected at least every six months. The industrial enterprises that were visited in Binh Thuan explained that the HW service providers would typically call the enterprise to organise the HW collection, so the HW service provider could organise HW collection and transport from several HW producers.

As described earlier, there are insufficient HW quantities in Binh Thuan and Bac Kan Provinces to justify the establishment of HW treatment facilities as the HW generation is less than 5,000 tonne/year.

Thus, in provinces where the industrial enterprises are generating smaller quantities of HW (e.g. Binh Thuan and Bac Kan Provinces), analysis should be carried out to determine whether the current joint stock companies should establish intermediate storage facilities for the HW. The intermediate storage facilities could operate as a collection station for the HW generated by the small HW generators in the province prior to the transport of the HW to the HW treatment facilities operating in the neighbouring provinces.

3.5.3 PRIVATE INVOLVEMENT

Currently, HW management in Vietnam is very well regulated, and all of the industrial enterprises that were visited are fulfilling the requirements regarding HW management, including storage of HW, entering into agreements with service providers, and reporting to DONRE regarding the enterprises' annual HW generation. The industrial enterprises that were visited have entered into service agreements with private and public enterprises providing collection and treatment of hazardous waste. The industrial enterprises have entered into individual agreements where the unit costs for collection and treatment of the different HW types are listed. The industrial enterprises pay the service provider directly for the HW collection and treatment services.

Based on the five visited hazardous waste treatment facilities and the list provided by MONRE, it was observed that the enterprises involved in collecting and treatment/disposal of HW are a mix of public enterprises, as well as private enterprises and joint stock enterprises.

3.5.4 INDUSTRIAL (HAZARDOUS) WASTE FINANCING IN VIETNAM AND EUROPE

Information has been collected regarding the typical gate fees charged for collection and treatment of HW in Vietnam. The gate fees (collection, transport and disposal) are presented in Table 3-18 together with information on typical gate fees (treatment and disposal) at typical hazardous waste treatment facilities in Europe.

TABLE 3-18 **Typical gate fee (collection, transport and disposal) for selected HW types in Vietnam compared with treatment costs in Europe**

Vietnamese HW code	HW type	Gate fee in Vietnam (VND/kg)	Typical gate fee in Europe (VND/kg)
08 02 01	Waste ink containing dangerous substances	4,000	17,250
08 02 04	Waste printing toner containing dangerous substances	1,000	Not available
08 03 01	Waste adhesives and sealants containing organic solvents or other dangerous substances	3,000	13,200
13 01 01	Infectious wastes (including sharps)	10,000 – 12,000	5,600
15 01 02	Oil filters	3,000	20,600
16 01 06	Fluorescent tubes and other mercury-containing waste	4,000	Not available[56]
16 01 09	Paint, inks, adhesives and resins containing dangerous substances	4,000	17,200
16 01 12	Batteries and accumulators	3,700	Not available[56]
16 01 13	Discarded equipment, electronic components or electronic equipment containing electronic components	6,000	Not available[56]
17 02 03	Synthetic engine, gear and lubricating oils	4,000	3,200-12,900[57]
17 02 04	Other engine, gear and lubricating oils	1,800	3,200-12,900[57]
17 03 04	Synthetic insulating and heat transmission oils	2,000	3,200-12,900[57]
17 03 05	Other insulating and heat transmission oils	1,800	3,200-12,900[57]
17 06 01	Fuel oil and diesel	2,000	3,400-13,100
18 01 01	Soft packaging	2,000	13,600
18 01 02	Hard packaging including empty pressure containers	10,000	13,600[58]
18 01 03	Hard packaging made of plastic	10,000	13,600
18 02 01	Absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	4000-6,400	16,600
19 05 02	Laboratory chemicals, consisting of or containing dangerous substances	6,400	17,200-34,000
19 06 01	Lead batteries	3,000	Not available[56]

Source: Data obtained from industrial facilities and general information obtained

The collection and treatment fees presented in Table 3-18 above are considerably lower than the typical international gate fees. In Europe, the gate fee for lubricant oil could range from 3,200-12,900 VND/kg depending on the water content and the content of halogens (chloride and sulphur). Similarly, the gate fee for oil filters is in the range of 20,600 VND/kg in Europe.

The gate fees for lead acid batteries and electronic waste in Europe is close to zero as an EPR (Extended Producer Responsibility) scheme has been established for these waste types. The collection and treatment expenses are paid by the vehicle owner/electronic consumer when purchasing a new lead acid battery/electronic item. The gate fee for

56 EU has introduced producer responsibility schemes for electronic waste and batteries
57 Gate is dependent on water content and content of halogens
58 Listed price is for incineration of contaminated metal packaging

infectious waste in Europe is relatively cheap compared to other HW types – it is in the range of 5,600 VND/kg as infectious waste is co-incinerated at municipal waste incinerators.

The table reveals that there is a significant difference in the level of treatment costs between Vietnam and Europe. A part of the difference can be explained by the differing price levels in Vietnam and Europe, which in turn, can be explained by the different treatment facility requirements, such as compliance with Best Available Techniques and higher environmental performance etc,.

3.5.5 LEGISLATION, MONITORING AND ENFORCEMENT

The Vietnamese legislative documents regarding hazardous waste management are very developed and includes the Law on Environmental Protection, several decrees, decisions and circulars on specific subjects, plus technical specifications on incineration.

The hazardous waste treatment facilities' and the industrial facilities' compliance with their environmental permits is monitored. For example, the flue gas emission at the hazardous waste incineration facilities are analysed on a quarterly basis.

Based on the observations made during the site visits conducted at the industrial facilities and treatment facilities, it is assessed that the decrees, decisions and circulars are not fully enforced. The following conditions have been observed during the site visits:

› Polluted/contaminated areas at one hazardous waste treatment facility which has been operating for several years
› Inappropriate disposal of incineration residues, i.e. in the green areas outside the incineration building
› Emission of black smoke from hazardous waste incineration facilities
› Disposal of mining residues in open areas
› Storage of steel production residues due to lack of disposal options
› Discussion between MONRE and the metal exploration enterprises on whether paste from floating process (extraction of lead and zinc) is to be classified as hazardous waste or non-hazardous waste

3.5.6 KEY CHALLENGES FOR INDUSTRIAL (HAZARDOUS) WASTE

Based on the analysis of the waste streams in the three selected provinces (Bac Kan, Thai Nguyen and Binh Thuan) and the hazardous waste treatment facilities in Hanoi, the following key challenges are identified:

› Lack of disposal options for several industrial hazardous and non-hazardous waste types, e.g. residues from mining activities and steel production, and dry ashes from energy production. The industrial facilities are forced to either store these waste types at own premises or dispose of the waste in an inappropriate manner.
› Lack of environmentally acceptable treatment /disposal options. The incineration facilities are not in compliance with international standards.
› Lack of a proper recording (database) of existing hazardous waste treatment facilities.
› Lack of regional planning for treatment capacities, which has led to the uncoordinated establishment of numerous small incineration plants (1,000-2,000 kg/hour)
› Lack of continuous flue gas emission measurements at incineration plants
› Insufficient flue gas treatment at incineration plants. Black smoke has been observed at some hazardous waste treatment facilities.
› Improper classification of residues from metal exploration

In order to address the above-mentioned challenges, the study has identified the following key action areas:

- Preparation of a national plan for management of industrial (hazardous) waste, distinguishing the different types of industrial (hazardous) waste streams
- Detailed investigations to determine whether the waste from the metal exploration enterprises is to be classified hazardous or non-hazardous, in particular lead-containing residues
- Establishment of proper treatment and disposal facilities for industrial waste originating from the mining industry, steel producing industry and the energy sector. The capacity of the facilities should be determined based on feasibility studies and should cover several provinces.
- Improvement of the legislative requirements for incineration facilities, including continuous monitoring of flue gas emissions and incineration temperature.
- Development of a database tool for logging the existing and future hazardous waste treatment facilities in Vietnam.

ANNEX 1: OVERVIEW ENVIRONMENTAL LEGISLATION

The Law on Environment Protection (LEP) 2014: This Law provides for environmental protection; for policies, measures and resources for environmental protection; and for the rights and obligations of organizations, households and individuals for environmental protection.

The law promotes waste reduction, reuse and recycling; and encourages organizations and individuals to use recycled and environmentally friendly products. This law emphasizes that organizations and individuals have responsibilities for waste reduction, reuse and recycling in order to minimize the amount of waste disposed as indicated in:

- *Article 82:* Requirement for environmental protection at household level to reduce, to separate the waste at generation sources,
- *Article 86* requires sorting all types of waste which can be recovered - 3R implementation to be focused.

Law on Environment Protection indicates that the advanced technologies for recycle and reuse of waste to create raw materials and generate energy shall be encouraged to apply and the minimization of solid waste volume to be landfilled shall be an important part of waste management policy for Vietnam.

Decree No. 81/2017/ND-CP of the Government dated 17 July 2017 on the functions, responsibility, rights, and organizational structure of Ministry of Construction

Decree No. 38/2015/ND-CP of the Government dated 24 April 2015 on the management of waste and scrap. The Decree was issued with the new approach on channeling the waste management according to the actors (actor or subject-oriented approach), including individuals/households and enterprises, which are different in terms of codes of practice as well as behaviors.

Decree No. 19/2015/ND-CP of the Government dated 14/02/2015 on guiding provisions of the LEP, which include regulations on ship recycling.

Decree No. 18/2015/ND-CP of the Government dated 14 February 2015 on environmental protection planning, strategic environmental assessment, environmental impact assessment and environmental protection plans. The Decree took effect from 1 April 2015.

Decree No. 15/2015/ND-CP of the Government dated 14/02/2015: Regulations on the field, conditions and procedures for the implementation of Public-Private Partnership Form.

Decree No. 15/2015/NĐ-CP of the Government: Regulations on the field, conditions and procedures for the implementation of PPP projects

Decree No. 114/2014/ND-CP of the Government dated 26 November 2014 regulates the subjects and conditions for importing and recycling used ships.

Decree No. 179/2013/ND- CP of the Government dated 14/11/2013 on Treatment of legal violations in environmental protection, forms, levels, competence, and procedures/remedies.

Decree No. 130/2013/ND-CP of the Government dated 16 October 2013: Regulations on the production and supply of products and public services

Decree No. 59/2007/ND-CP of the Government dated 09/04/2007 on Solid Waste Management indicates that solid waste disposal facilities shall be merged to serve for more than two provinces or shall be combined in a complex treatment facility, which includes garbage incinerators with energy recovery; organic waste fertilized plants, sanitary landfills for ordinary solid waste and landfills for hazardous solid waste etc.

Decision No. 491/2018/QD-TTg of the Prime Minister dated 07 May 2018 on approving the adjusted national strategy on integrated management of solid waste up to 2025, with a vision toward 2050

Decision No. 16/2015/QD-TTg of the Prime Minister dated 22 May 2015 on take back and treatment of discarded products.

Decision No. 73/2014/QD-TT of the Prime Minister dated 19 December 2014 on categories of scrap to be imported as production materials.

Decision No. 322/QD-BXD of the Ministry of Construction dated April 6, 2012 on announcement of investment and construction unit and rates for MSW treatment cost.

Decision No. 986/QD-BXD of the Ministry of Construction dated 17 November 2011 on planning for implementation of an Investment Program of solid waste treatment during the period 2011-2020.

Decision No. 798/2011/QD-TTg of the Prime Minister dated 25/05/2011 on approving the program for investments in solid waste treatment from 2011-2020.

Decision No. 184/2006/QD-TT of the Prime Minister dated August 10, 2006 on approval of the National Implementation Plan for Stockholm Convention on persistent organic pollutants.

Circular No. 41/2015/TT-BTNMT of the MONRE dated 09 Sep 2015 on environmental protection relating to importing and use of scrap as production materials.

Circular No. 36/2015/TT-BTNMT of the MONRE dated 30 June 2015 on management of hazardous wastes.

Other related documents:

Decision No. 577/2013/QD-TTg of the Prime Minister dated 11 April 2013 approving the Master program for environmental protection in craft villages towards 2020 and vision towards 2030.

Decision No. 170/2012/QD-TTg of the Prime Minister dated 08 February 2012 approving the master plan on hazardous solid medical waste treatment systems up to 2025.

Decision No. 2149/2009/QD-TTg of the Prime Minister dated 17 December 2009 approving the national strategy for integrated management of solid waste up to 2025, with a vision to 2050.

National Strategy on Integrated Management of Solid Waste (ISWM) to 2025, vision to 2050 issued on 27 December 2009, emphasizing the responsibility of the entire society, though the State plays a key role in mobilizing resources and increasing investment. ISWM also contains the prevention/reduction of waste generation and sorting of waste at source as a priority task of ISWM as well as promotion of reuse and recycling to minimize the amount of landfilled waste.

National Strategy for Environmental -

Protection until 2020 and Vision toward 2030 (issued by PM in 2012): The sanitation contents include objectives for drainage/sewage for 2020, which say that 100% of urban areas, industrial zones and processing zones are to be provided with centralized wastewater treatment system that meet environmental standards; inconsistencies in sewerage targets.

Decision No. 184/2006/QD-TTg of the Prime Minister dated 10 August 2006 approving the master plan to implement Stockholm Convention on Persistent Organic Pollutants.

National Technical Regulations and Standards

- **QCVN 01:2008/BXD:** National Technical Code on Construction Planning issued by MOC via the Decision 04/2008/QD-BXD dated 03/4/2008:

  "Solid waste treatment technologies, expected to be selected for application in solid waste disposal facilities, must be effective, in line with economic conditions, do not pollute groundwater, surface water and the ambient air environment.

  Proportion of solid waste processed by landfill technology does not exceed 15% of the total amount of solid waste collected.

  Proportion of solid waste processed by other technologies (recycling, reuse and composting …) shall be at least 85% "

- **QCVN 07-9:2016/BXD:** National Technical Regulation on Technical Infrastructure works on Solid Waste treatment and public toilets issued by MOC via Circular 01/2016/TT-BXD on first February 2016.

- **QCVN 61:2016/BTNMT:** National Technical Regulation on Domestic solid waste incinerator issued by MONRE via Circular No. 03/2016/TT-BXD on 10 March 2016.

- **QCVN 25:2009/BTNMT:** National technical regulation on wastewater of solid waste landfill sites

Standards:

- **TCVN 6696-2009:** Solid wastes - Sanitary landfill - General requirements for environmental protection

- **TCVN 6705:2009:** The classification of the non-hazardous solid waste.

- **TCVN 6707:2009:** Warning signs, prevention of hazardous waste.

- **TCXDVN 320:2004:** Hazardous waste burial sites – Design standard.

- **TCVN 7380:2004:** The solid medical waste Incinerator - Technical requirements.

- **TCVN 7381:2004:** The solid medical waste Incinerator - the evaluation and appraisal methods.

- **TCXDVN 261:200:1** Design standard for solid waste landfill

Document No.01/TB-VPCP dated January 02, 2013 of conclusions by the Deputy Prime Minister Hoang Trung Hai on current situation and solutions for solid waste treatment and implementation of solid waste treatment program period 2011-2020.

Many other documents specify the conditions of implementation, incentives related to the investment management of solid waste

Forthcoming legal framework

Draft documents of Prime Minister

- The Directive of Prime minister on strengthening solid waste management in rural areas.

- The Program on mitigation, classification of solid waste at source, reuse and recycling of solid waste up to 2020.

Priority policy Waste to Energy in Vietnam

Decision No. 2149 / QD-TTg of the Prime Minister dated December 17, 2009 on approving the National Strategy on integrated management of solid waste management towards 2025.

Decision No. 1440 / QD-TTg of the Prime Minister dated 06/10/2008 on approving the planning of DSW treatment centres for 3 key economic regions (North, Central and South) up to the year 2020.

Decision No.1216/QD-TTg of the Prime Minister approving the national Strategy for Environmental Protection until 2020 and vision to 2030.

Energy Recovery: Circular No.01/2001/ BKHCNMT-BXD on 12/02/2001 by the Ministry of Science, Technology and Environment, MOC regulations on environmental protection guidelines for site selection to build and operate waste landfills.

The scheme promotes environmental industries in Vietnam to 2015, vision 2025 "Decision No. 1030 / QD-TTg dated 20/7/2009"

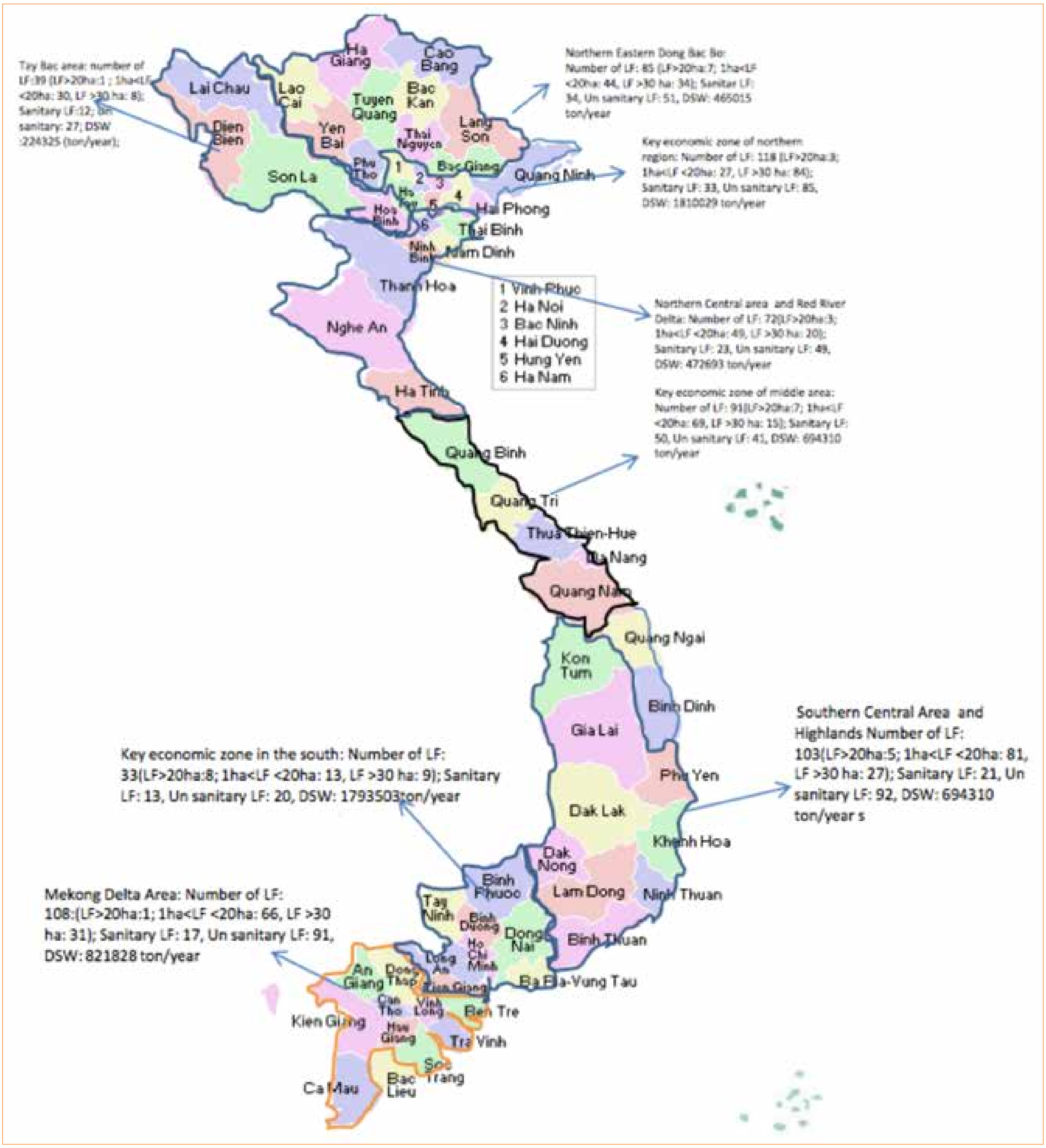
Some MSWM policies related to climate change:

Decision No. 2139/QD-TTg of the Prime Minister dated 05/12/2011 approved the national strategy on climate change as mentioned in Decision 130/2007 / QD-TTg on the mechanisms and financial policies for investment projects under the clean development mechanism;

Decision No.1775 /QD-TTg of the Prime Minister dated 21/11/2012: To approve the scheme management emission of greenhouse; managing the business operations of carbon credits to the world market

Mechanisms and policies to prioritize the development industry in Vietnam Electricity from solid waste: Exemption or reduction of land use fees or land lease; Import duty O&M supplies and equipment; O&M, reduce corporate income tax; support and the interest rate applicable under the CDM.

ANNEX 2: MAP OF LANDFILL LOCATIONS



Disclaimer: The map shown is for illustration purpose. The boundaries, color, denominations, and other information shown on any map in this work do not imply any judgment on the part of the World Bank Group concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

ANNEX 3: LIST OF LANDFILL LOCATIONS

TT	Province	KF	Sanitary	DSW (t/y)	Number of LF		
					>20ha	1ha -20ha	< 01 ha
Western North							
1	ĐIỆN BIÊN	9	2	30,638	0	4	5
2	LAI CHÂU	8	8	68,081	0	8	0
3	SƠN LA	13	0	93,440	1	11	1
4	HÒA BÌNH	9	2	32,166	0	7	2
Western North Provinces							
1	LÀO CAI	10	10	54,129	0	6	4
2	YÊN BÁI	10	1	61,320	2	6	2
3	HÀ GIANG	7	2	41,574	0	5	2
4	CAO BẰNG	12	4	22,490	0	8	4
5	BẮC KẠN	8	2	20,600	0	3	5
6	TUYÊN QUANG	5	1	44,799	1	1	3
7	LẠNG SƠN	7	7	94,518	1	4	2
8	PHÚ THỌ	4	3	93,805	0	4	0
9	THÁI NGUYÊN	6	2	116,800	3	3	0
10	BẮC GIANG	16	2	9,490	0	4	12
Economical zone of Northern							
1	QUẢNG NINH	13	5	306,923	2	11	0
2	HÀ NỘI	4	4	1,350,500	1	3	0
3	HẢI DƯƠNG	15	15	9,804	0	4	11
4	HẢI PHÒNG	6	4	15,422	1	1	4
5	HƯNG YÊN	3	2	26,048	0	3	0
6	VĨNH PHÚC	76	2	57,191	0	4	72
7	BẮC NINH	1	1	44,141	0	1	0
Economical zone of Red Delta River							
1	HÀ NAM	5	1	25,550	0	2	3
2	NAM ĐỊNH	5	4	41,304	1	4	0
3	NINH BÌNH	2	1	38,128	0	2	0
4	THÁI BÌNH	1	1	18,250	0	1	0
5	THANH HÓA (*)	33	3	80,300	2	18	13
6	NGHỆ AN	15	8	133,590		12	3
7	HÀ TĨNH	11	5	135,571	0	10	1

TT	Province	KF	Sanitary	DSW (t/y)	Number of LF		
					>20ha	1ha -20ha	< 01 ha
Economical zone of Middle and central							
1	QUẢNG BÌNH	9	7	55.453	1	8	0
2	QUẢNG TRỊ	33	15	37.470	0	23	10
3	HUẾ (*)	10	6	33.580	1	9	0
4	ĐÀ NẴNG	1	1	260.923	1	0	0
5	QUẢNG NAM	14	5	83.950	1	13	0
6	QUẢNG NGÃI	12	7	95.655	2	6	4
7	BÌNH ĐỊNH	12	9	127.279	1	10	1
Economical zone of Eastern South and High land							
1	PHÚ YÊN	9	1	76.285	0	7	2
2	KHÁNH HÒA	11	2	337.330	0	8	3
3	NINH THUẬN	19	2	38.820	0	14	5
4	BÌNH THUẬN	13	3	176.088	1	2	10
5	KON TUM	7	1	21.322	0	7	0
6	GIA LAI	17	5	116.963	0	16	1
7	ĐẮK LẮK	15	2	161.170	1	10	4
8	ĐẮK NÔNG	9	2	28.680	3	6	0
9	LÂM ĐỒNG	13	3	51830	0	11	2
Economical zone of Southern provinces							
1	TP.HCM	2	2	821.250	2	0	0
2	BÌNH PHƯỚC	6	1	22.018	0	5	1
3	TÂY NINH	2	1	61.784	0	2	0
4	BÌNH DƯƠNG	1	1	437.270	1	0	0
5	ĐỒNG NAI	4	4	227.953	3	1	0
6	BR-VT	3	2	191.150	2	1	0
7	TIỀN GIANG	7	2	19.833	0	3	4
8	LONG AN	8	0	12.245	0	4	4
Mekong Delta							
1	AN GIANG	14	1	131.808	0	8	6
2	CẦN THƠ	4	3	102.200	1	3	0
3	KIÊN GIANG	12	2	74.301	0	10	2
4	CÀ MAU	11	2	2.000	1	9	1
5	ĐỒNG THÁP	10	2	94.445	1	9	0
6	BẾN TRE	8	1	63.255	0	6	2
7	HẬU GIANG	3	3	58.948	0	3	0
8	TRÀ VINH	8	2	108405	0	7	1
9	SÓC TRĂNG	29	0	101.753	0	11	18
10	BẠC LIÊU	6	1	47.213	0	5	1
11	VĨNH LONG	4	1	37500	0	4	0
Total		**660**	**204**	**7.384.701**	**38**	**391**	**231**

ANNEX 4: NUMBER OF INDUSTRIAL ENTERPRISES VISITED

The present annex includes the number of industrial enterprises visited during the data collection missions.

Province	Name of enterprise	Type of enterprise
Thai Nguyen	Tien Bo Iron Mine, Thai Nguyen Iron & Steel JSC	Mining company (Iron)
	Luu Xa Steel Making Factory, Thai Nguyen Iron & Steel JSC	Steel production facility
	Viet Bac Colouring Metal Joint Stock Company, Ash Treatment Plant,	Incineration facility (treatment of WEEE and ashes from steel industry)
	Viet Xuan New Environment JSC	Hazardous waste treatment facility
Hanoi	Urenco 10	Hazardous waste treatment facility
	Industrial waste incineration plant	Industrial waste treatment (incineration) facility
Bac Kan	Na Tum Mine, Bac Kan Mineral Exploitation Company	Mining company (lead and zinc)
	Hoang Nam Company	Mining company (lead and zinc)
	Bac Kan Colouring Metal One member Co., Ltd	Mining company (lead and zinc)
Binh Thuan	Vinh Tan Thermal Power Plant	Thermal power plant
	Success Prosperity Shoe Material Company Limited	Sole producing enterprise
	Right Rich International	Shoe producing enterprise
	Viet Nam IST Ltd	Glass fiber/composite units production enterprise
	Nakagawa MFG Vietnam	Paper and cardboard production enterprise

ANNEX 5: ENVIRONMENTAL ADVANTAGES AND DISADVANTAGES OF TREATMENT OPTIONS

The present annex provides details in the environmental advantages and disadvantages for the proposed treatment options for the different identified industrial hazardous waste types.

TABLE A-1 **Environmental advantages and disadvantages for different treatment options**

Treatment options	Environmental advantages	Environmental disadvantages
Stabilisation by cement	Reduced contact between water and waste Formation of less soluble metal hydroxides and carbonates Easy to handle Release of pollutant (heavy metals) is relatively low on the short term	Use of additional resources (cement) Release of pollutants on long term is not know
Road construction	Reduced contact between water and waste, if road is impermeable No need for use of natural resources	Leaks in permeable layer (asphalt) can cause environmental pollution
Backfilling in underground mines	Stabilisation of decommissioned mine areas No need for use of natural resources	Short operation history (started in the 70'ies) Leaks can cause environmental pollution
Landfilling	Engineered landfills with liners are preferred compared to open dumps Possible use of methane gases	Contact between water and waste, i.e. release of pollutants to leachate and water sources Production of large quantities of methane, if organic waste is disposed of 30-50 years aftercare is needed to limit environmental impact from leachate Leaks can cause environmental pollution
Composting	Re-using of waste for soil improvement material Reduction of waste volumes Simple process Improves physical and biological properties of soil Enhance the chemical properties of soil	Possible spreading of pollutants (heavy metals and plastic) to clean soils Need of clean fraction (pure organics waste) with no pollutants, e.g. plastic Odour control is needed Nutrient composition is variable compared to chemical fertilisers
Biogas production	Renewable energy source Reduction of waste going to landfills Generates enriched organic manure (digestate)	Little technology advancement Biogas may contain impurities Need of sufficient supply of waste Not economic attractive in large scale compared to other biofuels
Soil improvement	Increased crop yields Improvement of agricultural soil without use of fertilisers Beneficial effect on soil structure	Possible spreading of pollutants (heavy metals) to clean soils Wastewater sludge may contain non-degradable components such as plastic Odour control is needed Runoff reaching water courses

TABLE A-1 Environmental advantages and disadvantages for different treatment options (cont)

Treatment options	Environmental advantages	Environmental disadvantages
Incineration at dedicated HW treatment facility	Waste volume reduction Elimination of hazardous components in the waste to less hazardous components Very widely proven Long operational history Broad range of wastes	Emission of pollutants via flue gas emissions Need for establishment of hazardous waste landfill for flue gas residues and bottom ashes
Co-incineration (cement plants)/ material recovery	Less need of natural resources No incineration residues Broad range of wastes	No long operational history Emission of pollutants via flue gas emissions High investment costs for flue gas treatment Limitation of halogen containing wastes

Source: Consultant's own knowledge and BREF note on treatment[46]

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