6.5 Measures and Projects for Achieving Clean City Environment: Establishment of Effective Solid Waste Management

6.5.1 Basic Concept

(1) Slogan

Good solid waste management is summarized in the following proposed slogan:

- "Better and more service with higher efficiency"

(2) Principles

The proposed principles concerning solid waste management of Hanoi are as follows:

- Application of cost-effective and environmentally sound methods particularly for waste collection, transport and disposal
- 100% waste collection service coverage for all urban population
- Increases of cost recovery through fee collection
- Strengthening of the responsibility and capacity of Districts in solid waste management
- Promotion of privatization
- Strengthening of the responsibility of enterprises for the management of industrial waste

(3) SWM Service Targets

The following service targets are proposed:

- Provide waste collection service for all urban population by 2007
- Implement a complete sanitary landfill in Nam Son by 2004
- Increase the efficiency of waste collection and transport through institutional reform and operational improvement by 2002
- Achieve 100 % cost recovery by the year 2005

(4) Major Measures to Achieve the Targets

In order to achieve the above targets, the following measures are proposed:

A. Institution

- Shift responsibility of solid waste management to the District administration from HPC (TUPWS)
- Privatize solid waste management services in the form of "contracting out"
- Transform URENCO into a pure service provider
- Increase cost recovery from waste generators, i.e. households and industries

B. Municipal Waste Collection and Transport

- Promote use of waste bins (350 – 700 liter) or bagbags of degradable type to avoid waste scattering and increase waste collection efficiency
- Apply direct collection system for collection of solid waste (with trucks but without handcarts) instead of the existing two steps collection system with handcarts and trucks
- Renew and procure necessary collection equipment (trucks) and develop new garages and a workshop for maintenance
- Develop a waste transfer system (construction of a transfer station in Dong Ngac and procurement of secondary transport vehicles)

C. Municipal Waste Disposal

- Secure land of adequate area for landfill, and construct a landfill site in Nam Son
- Apply a sanitary landfill as major means of non hazardous waste disposal
- Apply composting only if its economic feasibility is confirmed.

D. Hospital Waste Management

- Apply incineration as major means of disposal of medical solid waste
- Collect and incinerate all medical solid waste

E. Industrial Waste Management

- Enforce the regulation that stipulates the responsibility of industrial waste generators to manage their own waste
- Promote establishing joint venture companies that provide industrial waste collection and treatment service

6.5.2 Institutional and Regulatory Measures

This section explains the institutional proposals as an integral part of the Hanoi Environmental Master Plan. The basic direction shown by these proposals has been discussed and agreed with the Vietnamese side, in particular the Steering Committee for this JICA Study. However, these proposals are worked out as an integral part of the Environmental Master Plan for Hanoi and therefore, it is advised that in-depth and detailed study should be carried out to give body and substance to these proposals and concrete plans should be worked out with specific measures. In particular, measures proposed for privatization should further be looked into carefully by HPC itself from various viewpoints including its economic and financial feasibilities and the way of involvement and supervision by the Government.

These proposals should be understood in this context.

- Shift responsibility of solid waste management to the District administration from HPC (TUPWS)
- Privatize solid waste management services in the form of "contracting out"
- Transform URENCO into a pure service provider
- Increase cost recovery from waste generators, i.e. households and industries

(1) Shift responsibility of solid waste management to the District administration from HPC (TUPWS)

At present, Department of Urban Transport and Public Works (TUPWS) is responsible for administering solid waste management within urban districts, and URENCO is responsible for providing solid waste management service. In sub urban districts, each sub urban district is responsible for providing solid waste management.

It is proposed that HPC will shift the responsibility of solid waste management to each urban district. Being responsible for SWM means to take ultimate care of solid waste management, and does not necessarily mean that a responsible body should provide SWM service by itself. Major options are:

- Use employees and equipment of their own
- Contract out SWM services

The reasons for proposing this shift are as follows:

1) SWM service is a community-based service by nature

Collection of solid waste is a community-based service that requires local residents' cooperation. District administration is the most appropriate level of administration that can have contacts with local residents.

2) Size of Population is large enough for district to provide efficient service

In Hanoi, each district has population of 200,000 to 400,000. Population of this size is large enough for a district to provide efficient solid waste management service.

3) District administration is financially and administratively capable

In the past, each district administration used to be responsible for solid waste management. The need for applying a capital intensive waste collection method (use of trucks) has necessitated establishing a municipal organization

like URENCO. With economic growth, it is financially and administratively possible for each district to purchase trucks. Gia Lam sub urban district has proven this point.

4) Ultimate caretaker (District) will have more choices regarding way of providing service

Once a District is held responsibility for ultimate care taking of solid waste management, the District would have choices as to:

- Whether to use own employees and equipment of its own (direct service by district) or external companies (contracting out).
- which parts (areas) of district should be contracted out
- which types of services (street sweeping, collection and transport, watering streets) should be contracted out
- when to be contracted out
- conditions of contracts

5) Possibility for cost reduction

Because of availability of the above choices, there is a possibility to reduce costs of SWM services. It is likely that other districts will follow a District that has proved to be successful in solid waste management

(2) Privatization

1) Form of Privatization

For waste collection, transport, and street-sweeping services, "contract out" is the most appropriate form of privatization. Contract out is to arrange provision of SWM service by using contractor based on conditions and terms agreed between contractor and client.

For treatment and disposal of solid waste, BOO (Build, Own, and Operate) or the concession are applied in some cities in Britain and France or other countries. In France concession is common. BOO and concession are generally termed as Project Financing Initiative (PFI). In either case, contractors are remunerated based on quantity of solid waste disposed of. The other form of privatization of waste treatment and disposal services is the management contract. A selected contractor is responsible for operation and maintenance of the facilities such as incinerator or landfill facilities owned by local government.

2) Reasons for Proposing Privatization

(a) Reduction of SWM Cost

Experiences in many countries show the privatization of SWM service leads to reduction of SWM cost by 10% - 40%. Cost reduction by one third (33%) seems to be common. Under the current setting, URENCO does not have much incentive to be more efficient.

(b) Expansion of Service Area

With savings made through cost reduction, it is possible for Districts to expand waste collection service areas.

(c) Improvement of Service Quality

Experiences in many cities of the world show that quality of SWM services improve though privatization. Clients (Districts) have choice to replace a contractor with another one if the service quality is not satisfactory. This condition gives contractors an incentive to provide better service with less cost.

(3) Arrangement for Shifting SWM Responsibility to Districts and Arrangement for Privatization

Time schedule shown in this section is only example. Detailed strategy, plan and schedule should be worked out by HPC in the near future. Hanoi Socio-Economic Development Research Institute would be capable of drafting such strategy and plan.

Step 1: UEE receives vehicles (by 2000)

Each Urban Environment Enterprise (UEE) will be given waste collection vehicles and other necessary equipment and facilities including garages. In reality, this change will be done by transferring staff and equipment of the Transport Units to UEEs. In March 2000, URENCO has already decided to implement this change. UEE will also assume responsibility of collection of demolition waste and soil waste.

Step 2: UEE will be placed under District Administration (2001 – 2005)

The existing 5 Urban Environment Enterprises (UEE) will be detached from URENCO, and placed under the District Administration during 2001 – 2005.

- UEE 1 will be administered jointly by Ba Dinh District and Cau Giay District
- UEE 2 will be administered by Hoan Kiem District
- UEE 3 will be administered by Hai Ba Trung

- UEE 4 will be administered jointly by Dong Da and Thanh Xuan
- UEE 5 will be administered by Tay Ho District

An important condition for this change is that UEE would be provided with adequate equipment such as waste collection vehicles.

Each UEE will provide waste collection service in the same manner as before. HPC will allocate corresponding budget to each District.

Step 3: Districts will be responsible for fee collection (2001)

Each Urban District will assume responsibility for collecting fees from service recipients (households, and governmental, commercial and industrial organizations).

Step 4: UEE will partly or wholly contract out waste collection service (2001 - 2005)

HPC should guide Urban Districts to contract out part of their service in some areas. With emergence of new business opportunities, the private sector would establish private companies that can provide waste collection and street sweeping/watering services. If there will be a few companies, the competition for "better service with less cost" will set in. HPC and Districts should prepare guidelines concerning standards and conditions of SWM services applicable to contractors. HPC should take measures to strengthen the Districts' capacity in contract management.

It is advisable that the said contracting out (privatization) should be done first in non-central districts, and in central districts later. The Hanoi Socio-Economic Development Research Institute proposed the following time schedule:

Districts	Timing of Contracting Out through Tender
- Cau Giay & Thanh Xuan	2001 – 2002
- Tay Ho, Hai Ba Trung and Dong Da	2003
- Hoan Kiem and Ba Dinh	to be decided based on results of formers

Step 5: URENCO will be detached from HPC (by 2005)

URENCO will be detached from HPC, and become an independent company. URENCO will have contracts with each Urban District for provision of services for the secondary transport and disposal. URENCO will recover cost though contracts, and will not receive any subsidies. At this stage, URENCO will continue to monopolize the waste transfer and disposal business. However, because URENCO recovers all costs in the form of fees instead of subsidies, URENCO will have an incentive to do more service with less cost.

Step 6: Privatization of secondary transport and disposal services (2005 – 2010)

HPC will change monopoly policy of URENCO's service, and encourage that some companies will be established that can provide the secondary transport service. In future, HPC should also encourage private sector to participate in BOO arrangements for waste treatment and disposal. Simultaneously, HPC should establish a regulatory agency that will set standards of waste treatment and disposal services, and monitor compliance of companies.

6.5.3 Collection and Transport Plan for Municipal Waste

(1) Target Collection Quantity

- Provide waste collection service for all population living in urban areas both in Urban Districts and Suburban Districts.
- Urban Districts will increase waste collection amounts so that they will collect 95% of waste generation amount in 2007 and thereafter.
- Suburban Districts will increase collection at annual increase rates ranging from 6 – 10% depending on district and period, and will reach 65% collection rate in 2020.

1) Urban District

As of the beginning of 1999, it is estimated that URENCO collects about 1,300 ton per day including demolition waste and soil waste, 77% of the estimated generation amount of 1,700 ton/day.

In terms of the collection service coverage by population, URENCO should provide 100% of the urban population with waste collection service. However, technically, 100% of service coverage is unlikely in terms of waste quantity.

It is proposed that that URENCO will increase collection amount at rate of 8% until the collection rate reach 95% in 2007. Thereafter, URENCO's collection rate will remain at 95% by increasing waste collection at same rates as generation increase rates. Table 6.5.1 shows annual amounts of waste generation and collection during the period 1998 – 2020. Information for selected years is shown below.

Target Waste Collection and Projection of Waste Generation Amount in the 7 Urban Districts of Hanoi

Year	Target Collection (ton/day) (a)	Projected Generation (ton/day) (b)	Collection Rate (a)/(b) = (c)
1999	1,317	1,708	77%
2005	1,935	2,184	91%
2007	2,396	2,522	95%
2010	2,763	2,908	95%
2020	3,954	4,162	95%

Table 6.5.2 shows target collection amount by district. Table 6.5.4 shows waste received at Dong Ngac transfer station and Nam Son landfill.

Current waste flow from generation to collection and disposal is shown in Fig.6.5.1. Fig.6.5.2 shows the planned future waste flow in 2004 when the planned transfer system and Nam Son Phase 2 Landfill site is open.

2) Suburban District

At present, each Urenco of suburban districts provides collection service for town (district center) and few communes surrounding communes (out of about 25 communes) in each district. Except for Gia Lam suburban district that established its Urenco in 1989, the other 4 suburban districts of Hanoi established Urenco in each district in recent years during 1994 – 1998.

The longer the history of Urenco, the more waste it collects. As of the beginning of 1999, Gia Lam district collects 48 ton/day, and the other 4 sub urban districts collect about 20 ton/day of waste each. Rates of collection relative to generation are estimated to be 37% in Gia Lam, and 20 – 30% in the other 4 districts.

It is projected that waste generation amount in sub urban districts will increase at rates from 2 – 4 %/year. Target waste collection amount must increase 6 – 10%/year.

Because each suburban district is responsible for solid waste management within each district area, target collection amounts and resulting collection rates are set for each suburban districts as shown in Table 6.5.3. Summary is shown below. In principle, each suburban district should provide waste collection service for all urbanized area.

Target Waste Collection and Projection of Waste Generation Amount in the 5 Suburban Districts of Hanoi

Year	Target Collection (ton/day) (a)	Projected Generation (ton/day) (b)	Collection Rate (a)/(b) = (c)
1999	133	470	28%
2005	204	570	36%
2010	294	671	44%
2020	586	908	65%

(2) Collection and Transport Method

1) Issues

The Study Team considers that the major issues with respect to waste collection and transport are as follows:

- Increase level of cleanliness of streets
- Increase efficiency of waste collection and transport.
- Achieve 100% collection coverage in terms of population for urbanized areas irrespective of whether they belong to urban districts or suburban districts.

2) Measures to Increase level of Cleanliness of Streets

Some people in Hanoi put solid waste on streets without using any containers or bags. Ash of charcoal briquets dumped on streets without containers are often seen on streets. Such unsealed waste is a major cause of unclean streets.

- To avoid this situation, HPC should make it compulsory to use either:
  a. containers (350 liter – 700 liter) that can be mechanically lifted by collection trucks or
  b. bagbags of degradable type
- Do not use communal containers (6 – 8 m3) in the city center as they can often be causes of unsanitary conditions though they can be used in suburban areas.
- Improve the design of dustbins placed in public spaces. They should be larger and easier to empty.

The above containers or bags must be ones that are compatible with collection system.

Containers can be placed in residential area with apartment buildings or

other places where there are enough spaces that are accessible by collection trucks. It is local residents who put waste into these containers. Use of this type of containers will enable to substantially increase efficiency of waste collection.

It should make it compulsory to seal bagbags after putting solid waste.

3) Measures to Improve Efficiency of Waste Collection and Transport

- Apply direct collection system instead of two step collection with handcarts and trucks because the direct collection system is more efficient
- Citizens will use either bags of degradable type or designated containers
- Collection workers instead of local residents will put waste into trucks
- Establish a transfer system with a transfer station in Dong Ngac

(a) Direct Collection

It is rational to move from a labor intensive system (such as the prevailing collection system) to capital intensive system as labor costs increase in future.

The Study Team has estimated and compared costs of both the prevailing system and direct collection system for Hanoi. The result indicates that under the current conditions, cost of collection and transport would be lowered by about 1 million dollar per year by switching from the prevailing collection system to the direct collection system. The cost difference between the two systems will be larger with rise of salaries of URENCO workers and increases in waste collection amount. If both salary and waste collection are doubled, the annual net saving will be 3.7 million dollar as shown in the following table.

Cost Saving to be Gained by Shifting from the Two Steps Collection System to Direct Collection with Trucks

Cases	Major Assumptions			Annual Costs		
	Waste Collection Amount (ton/day)	Salary of Handcart Worker ($/month)	Salary of Truck Driver ($/month)	Handcart Collection & Truck Transport ($/year)	Collection & Transport with Truck ($/year)	Annual Cost Difference ($/year)
	a	b	d	d	e	f = d + e
Case 1: No changes in salary rates and waste collection amount	800	40	50	2,627,650	1,683,621	944,029
Case 2: Salary rates are doubled	800	80	100	3,787,741	1,909,152	1,878,589
Case 3: Salary & waste collection amount are doubled	1,600	80	100	7,575,483	3,818,304	3,757,179

Detailed calculations and assumptions for each case are shown in Tables 6.5.5, 6.5.6 and 6.5.7.

Comparison of Hanoi URENCO with Da Nang Urenco

The JICA Study Team members visited Da Nang and Hoi An where a direct collection system is applied. Based on the information obtained from Urenco of Da Nang and URENCO of Hanoi, the Study Team has estimated unit costs of waste management (collection, transport, treatment and disposal) per ton for both cities. The unit costs were obtained by dividing the total annual expenditure by total annual waste collection amount.

This simple comparison indicates that the unit cost of Hanoi URENCO ($12/ton) is 2.4 times higher than that of Da Nang Urenco ($5/ton). Another comparison is made in terms of amount of waste managed per employee per day. Waste amount managed by Da Nang Urenco (0.55 ton/employee/day) is 1.4 times larger than that managed by Hanoi URENCO (0.39 ton/employee/day). These are significant difference even though there are difference in conditions such as Hanoi URENCO is engaged in composting while Da Nang Urenco is not. Both cities apply largely an open dumping.

Comparison of Da Nang URENCO and Hanoi URENCO in 1998

	Da Nang	Hanoi
a. Amount of waste collected	250 ton/day	1,250 ton/day (note 1)
b. Number of employees	450 persons	3,200 persons
c. Collection amount per employee (a/b)	0.55 ton/day (Index: 141)	0.39 ton/day (Index: 100)
d. Expenditure	$450,000/year	$5,500,000/year
e. Unit cost: d/(a x 365 days)	$4.93 (Index: 100)	$12.05 (Index: 244)

Note 1: Of 1,250 ton/day of waste collected by Hanoi URENCO, 250 ton/day is demolition waste and soil waste.

(b) Use of Waste Containers or Bags

Use of waste containers and bags are pre-requisite to have an efficient direct collection. Application of these is explained in the previous section.

(c) Loading of Waste into Trucks by Collection Workers

In Vietnam, bell collection system is widely applied where local residents come out of houses by hearing bell ringing, and put waste into handcarts or trucks. However, it is proposed that waste collection workers who move with trucks should load waste into trucks. This is more efficient than the other prevailing system.

As life standard of citizens rises, less number of people are at home when waste trucks arrive, and also citizens would feel that it is inconvenient for them to synchronize waste discharge action with truck with truck arrival. With this tendency, it will be increasingly difficult and less economical to maintain the bell collection system.

In case citizens use bags, the bags should be closed tight, and placed in the frontage of houses or at places of types to be designated by HPC. In case citizens use containers (350 – 700 liter), they should be placed in designated areas that are accessible by collection trucks. The containers are lifted and emptied mechanically by collection trucks.

(d) Establishing a Waste Transfer System

Because Nam Son landfill is about 50 km away from the waste collection areas, waste transport with a transfer system is more economical than the one without transfer system. The JICA Study Team has conducted a pre-feasibility study for the transfer system. It is strongly urged that HPC will make arrangements for acquisition of necessary funds and land at the

planned location in Dong Ngac and necessary funds.

(c) Railway as a Mode of the Secondary Transport

The JICA Study Team considers that in Hanoi the road transport of waste has much more economical and operational advantages than the railway transport does, and therefore recommends the road transport for HPC. Implementation of the railway transport of waste to Nam Son landfill site will require much higher cost than the road transport and longer time for preparation. The Study Team's comments on the railway transport of waste to Nam Son are as follows:

- In case of railway transport, two waste transfer facilities will be needed, i.e, one at a waste loading station to be located near waste collection area and the other at a waste unloading station (terminal) near the landfill site. Trucks will be needed to transport waste from the terminal to the landfill site.
- Road transport of waste is an established system tested and experienced by many cities of the world, while railway transport is rare (a few cases in Europe including France, Netherlands, and Germany). In Japan, there is only one city (Kawasaki city) that has applied a railway transport of some waste to an incinerator.
- In Japan, it is generally considered, railway transport of waste may be economically feasible if the transport distance is more than 500 km.
- It should be noted needs for transport of waste to an incinerator exist semi permanently as old incinerators can be replaced with new one, while the demand for transporting waste to a particular landfill site will end with the end of life of this particular landfill site.
- Some people consider that the railway transport is environmentally sound, as it does not emit much gas emission. However, it should be noted that the secondary transport of waste on roads causes much less gas emission than the primary transport activity does because the secondary transport uses large capacity vehicles that results in less number of trips and less gas emission.
- In case of Hanoi, the following factors should be considered if HPC is interested in the railway transport.
  a. availability of land for construction of extension of railway and transfer facilities
  b. time needed to investigate, carry out an environment impact assessment, make plan and design, acquire necessary land, and construct facilities

c. duration of Nam Son landfill operation period
d. cost of design, construction and supply of all necessary equipment and facilities including transfer facilities at both ends
e. cost of road transport from Nam Son railway terminal to the Nam Son Landfill site.
f. Cost of construction of an bridge for National Road No.3 (A future extended railway to Nam Son will inevitably cross National Road No.3, and therefore, a bridge must be constructed for National Road No.3 to cross over the future railway extension line.)
g. costs of compensation to local people who have to be relocated or will be affected due to construction of transfer stations and railway extension.

(3) Requirement of Collection and Transport Equipment

1) Type of Equipment to be Procured

Major equipment to be procured is as follows:

- Waste collection trucks
- Night soil trucks
- Water sprinkling vehicles
- Containers (350 – 700 liter)

2) Quantity and Cost of New Purchase

At present, URENCO possesses about 150 vehicles for waste transport. Most vehicles used by URENCO are purchased before 1993, and need to be replaced. Additional trucks are needed to transport incremental waste. It is planned that these old trucks will be replaced by new ones by 2005. It is estimated that a total of 250 waste collection trucks need to be used in 2005 in order to collect target quantity of solid waste. During 2000 – 2005, 230 waste collection trucks and 40 vehicles for water sprinkling and 1,000 containers will be newly procured. Total costs of the procurement of the vehicles and containers during 2000 – 2005 are estimated to be about $32 million. Equipment requirement, procurement schedule, and estimated costs are shown in Tables 6.5.8, 6.5.9 and 6.5.10 respectively.

(4) Garages, workshops and maintenance facilities

1) Existing Garage Facilities

The location of garage facilities is shown on Figure 6.5.3. Transportation garages and the central maintenance facilities are overcrowded, and poorly

equipped for vehicle maintenance. As a result most regular daily maintenance is carried out in the open unpaved parking area where dust and grit present less than ideal conditions for mechanical maintenance. Several minor repairs that could be carried out at the transportation garages must be deferred until they can be scheduled at the central mechanical workshop; this can result in operating vehicles under duress, with the possibility of reducing service life.

Workshops are required at existing garages to improve the capacity for providing daily preventive maintenance and minor repairs to collection vehicles. Furthermore, new garage facilities are needed to alleviate the shortage of space that will soon be aggravated by the increase in the number of vehicles for waste collection, and street washing activities.

The existing allocation of garages by transport unit is presented in the following table:

Existing Transportation Garages

Garage Site	Location (District)	Transport Units	Districts Served	Vehicles 1999		Total
No.1	Thuy Khe St. (Tay Ho)	Transport Unit No.1	Ba Dinh, Cau Giay, Hoan Kiem	Collection	53	101
		Transport Unit No.3	All districts	Water Trucks	43	
		Enterprise No.5	Tay Ho	Collection	9	
No.2	De La Thanh (Dong Da)	Transport Unit No. 2	Hai Ba Trung, Dong Da, Thanh Xuan	Collection	78	78
No.3	85 Lang Ha (Dong Da)	Transport Unit No. 3	All districts	Septage Pumping	17	17
No.4	Former Me Tri landfill (Thanh Xuan)	Transport Unit No. 4	All districts	Demolition Waste	11	11

Street washing vehicles can only operate from garage no.1 because it is the only garage that has a water filling station.

Garage sites no.1 and no.2 are located in densely populated urban areas and there is no space available for expansion unless neighbouring residents are expropriated.

Garage no. 3 is used exclusively for parking septage collection trucks, bucket latrine collection trucks and storage of portable public latrines. The facility consists of a small operating yard hemmed in on four sides by commercial development. There is no garage building, no truck washing facilities and only one small office space for the manager and administrative

staff of enterprise no.3. There is no space for growth of the septage collection fleet.

Transportation garage No.4 is located at the former Me Tri landfill site. Although facilities are at present rudimentary there is ample space for parking and construction of new garage facilities.

The number of vehicles required for collection and transportation of waste, and street-cleaning activities will increase and create a need for new facilities. In order to assess how many facilities are required it is first necessary to estimate how many vehicles could be operating in the future.

2) Increase in Number of Solid Waste Collection Vehicles

The number of collection vehicles used to haul domestic household waste to the transfer station will increase to match population growth and improved service levels. The number of collection trucks required to serve Hanoi's 7 urban districts is based on estimates of the waste quantities that will be generated in each urban district.

3) Increase in Street Washing Vehicles

Street dust is a significant source of air pollution in Hanoi. It is common to see cyclists and motorcyclists wearing facemasks to prevent inhaling dust. There are many sources of dust:

- There is extensive construction in Hanoi and waste materials such as sand, stone, brick and cement are dumped onto the side of the street
- Transportation of construction materials is in open containers
- Waste is disposed of directly on the street adding to the level of street waste.

The sum of these factors contributes to significant levels of dust that affect air quality and potentially public health. It is therefore necessary to have an effective system for street cleaning which must be carried out on a regular basis.

URENCO has determined that it should clean approximately 120 km of streets per day based on experience. It has consistently fallen well short of that target because it lacks equipment and facilities. Currently URENCO has 42 water trucks used to clean approximately 56 km of streets per day. The existing fleet is old and service levels have decreased every year since 1994.

In the short-term it is assumed that the number of street cleaning/washing vehicles should increase by 3 vehicles per year until the year 2005. The

increase in vehicles can then be reduced to one per year from 2006 to 2010 on the assumption that the amount of waste thrown on the street will be greatly reduced with the introduction of household waste containers and the implementation of direct collection. It is also assumed that improvements in collection of construction and demolition waste will result in less dust on the streets.

Assumptions about the total number of street washing vehicles are summarized in Table 6.5.11.

4) Septage Collection Trucks

The Cau Dien compost facility is the only formal treatment facility available and has a limited capacity of approximately 10 tons per day to treat septage. Increasing the amount of septage collected by URENCO would aggravate the waste disposal problem because there are no other treatment facilities available. Therefore, it is assumed that until treatment facilities are constructed there should be no improvement in URENCO's collection capacity. The existing collection vehicles are old and should be replaced in the near future with vehicles that have more suction power and larger tank capacities.

Projected vehicle requirements estimated elsewhere in the master plan for septage are summarized in Table 6.5.12.

5) Garage Facility Requirements

Review of site conditions indicates that existing garages should accommodate fewer vehicles than they currently do in order to improve parking and operating conditions. Therefore it is assumed, based on experience, that existing garages have capacity for no more than 75% of the present number of vehicles. Vehicles are allocated to enterprises and compared to maximum garage capacities to the year 2010 in the following table:

Future Number of Vehicles

Facility	Location/ (District)	Transport Units	Estimated Vehicle Capacity 0.75 X (1)	Vehicles	Year 1999 (1)		Year 2005		Year 2010	
Garage No.1	Thuy Khe St./(Tay Ho)	Transport Unit No.1	80	Collection vehicles	53	105	76	158	100	200
		Transport Unit No.3		Water Trucks	43		61		66	
		Enterprise No.5		Collection vehicles	9		21		34	
Garage No.2	De La Thanh/ (Dong Da)	Transport Unit No. 2	60	Collection vehicles	78		118		153	
Garage No.3	Dong Da (85 Lang Ha St.)	Transport Unit No. 3	15	Septage Pumping	17		12		14	
Garage No.4	Me Tri landfill site/ (Thanh Xuan)	Transport Unit No. 4	100	Demolition Waste	11		17		23	
Total					211		305		390	

The table demonstrates that new garage facilities will be required in the very near future. The number of new garage facilities required and their location will depend not only on the number of vehicles but more importantly on how URENCO decides to re-organize its service delivery in the near future.

6) Impact of proposed re-organisation on service delivery

Under the recommended re-organisation plan, it is proposed that solid waste services would be provided by five separate district based "sanitation enterprises" each responsible for:

- the collection of domestic waste,
- the transportation of waste to the transfer station
- the collection and transportation of demolition waste, and
- street washing within the specified urban districts.

Existing Operational Organization

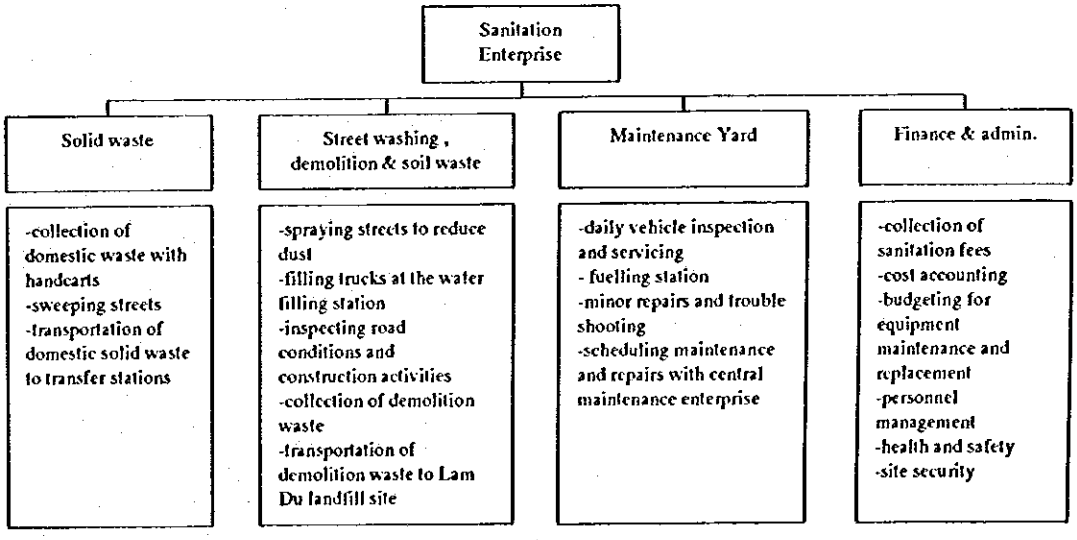
Function	Districts						
	Ba Dinh	Cau Giay	Hoan Kiem	Hai Ba Trung	Dong Da	Thanh Xuan	Tay Ho
Septage Waste collection	Transport Unit no.3						
Street watering							
Demolition Waste	Transport Unit no.4						
Collection/street sweeping	Enterprise No.1		Enterprise No.2	Enterprise No.3	Enterprise No.4		Enterprise No.5
Transport to Landfill	Transport Unit no.1			Transport Unit no.2			

Operationally, existing Collection Enterprises and Transportation Units would be grouped together and re-allocated on a district basis as shown in the following tables:

Proposed Operational Organization

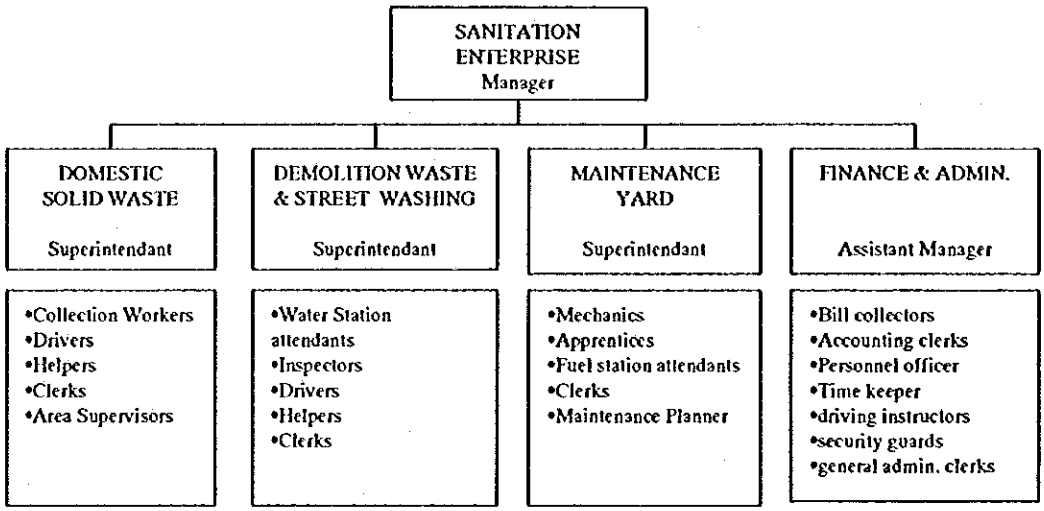
Function	Districts						
	Ba Dinh	Cau Giay	Hoan Kiem	Hai Ba Trung	Dong Da	Thanh Xuan	Tay Ho
Septage Waste collection	Transport Unit No.3						
Street watering	Sanitation Enterprise No.1		Sanitation Enterprise No.2	Sanitation Enterprise No.3	Sanitation Enterprise No.4		Sanitation Enterprise No.5
Demolition Waste							
Collection/street sweeping							
Transport to transfer station							
Transport to Landfill	URENCO Transfer Enterprise						

Personnel providing septage and nightsoil collection services in Transport Unit no.3 will continue to operate as a separate functional group serving all districts. In the near future, this unit can be separated from URENCO if required. Personnel in Transport Unit No.3 providing street-washing services will be re-allocated to one of the 5 Sanitation enterprises as will personnel from Transports Units No.1 and No.2. Physically some minor adjustments will be required to collection routes. The total number of personnel does not change as a result of the re-organisation. A functional organisation chart for a typical sanitation enterprise is presented in the figure below:



Functional organisation chart for typical Sanitation Enterprise

Personnel should be assigned to working units on the basis of the proposed functional organisation. A proposed organization chart showing required personnel, management responsibilities and lines of reporting is shown in the figure below:



Organizational Structure for Typical Sanitation Enterprise

A superintendent responsible for day to day operations should head each functional unit. Superintendent report directly to the manager of the enterprise who has overall planning and fiscal responsibility for all sanitation activities in the district(s) served by the enterprise.

An example of how the vehicles from Transportation Units no.1 and no.2 can be allocated by district in the future is presented as follows:

Allocation of vehicles on a district basis

District	Enterprise	Household Waste Transportation			Demolition Waste			Street Washing			Total		
		1999	2005	2010	1999	2005	2010	1999	2005	2010	1999	2005	2010
Ba Dinh	Enterprise No.1	30	51	71	4	5	7	10	14	15	44	70	93
Cau Giay													
Hoan Kiem	Enterprise No.2	20	25	29	2	2	3	5	6	8	27	33	40
Hai Ba Trung	Enterprise No.3	37	46	54	3	3	4	12	18	19	52	67	77
Dong Da	Enterprise No.4	40	72	99	3	5	7	12	18	19	55	95	125
Thanh Xuan													
Tay Ho	Enterprise No.5	10	21	34	2	2	2	4	5	5	16	28	41
Total		137	215	287	14	17	23	43	61	66	194	334	376

Note: Septage pumping vehicles are not included

The numbers leave no doubt that new garage facilities are required to accommodate a growing fleet. The number of facilities, their location, and the amenities provided at each is reviewed to determine the optimum re-allocation of existing facilities and to provide a plan for the cost-effective development of new facilities until 2010. Between 2010 and 2020 it is predicted that the private sector will play an important role in primary collection. Therefore, no new URENCO garage facilities are planned after 2010.

The first objective in allocating new garage facilities is to solve the shortage of space. Secondly and equally important, is the need for locating the operating base for each sanitation enterprise as close as possible to the district it serves.

An example of how garage facilities can be allocated in the near future is shown in the following table:

Allocation Of Garages On A District Basis – Year 2000

NEAR FUTURE – YEAR 2000							
Garage No. (maximum vehicle capacity)	Ba Dinh	Cau Giay	Hoan Kiem	Hai Ba Trung	Dong Da	Thanh Xuan	Tay Ho
Garage No.1 (80)	Enterprise No.1 (44)						Enterprise No.5 (16)
Garage No.2 (60)			Enterprise No.2 (27)	Enterprise No.3 (52)			
Garage No.3 (15)	Transport Unit No.3 (Septage trucks and bucket latrines only)						
Garage No.4 (expanded for 120)					Enterprise No.4 (55)		

The proposed near future re-allocation of garage facilities will involve a number of moves and facility upgrades:

- Vehicles presently serving Hoan Kim District are moved from Garage No.1 to Garage No.2. This will alleviate the space shortage at Garage No.1.
- Collection vehicles serving the Dong Da and Thanh Xuan districts are moved to a new garage No.4 at Me Tri to alleviate space shortage at Garage No.2. The number of vehicles at Garage No. 2 will remain over the estimated optimum capacity in the near future but will be no worse than existing levels.
- Garage No. 2 will need a water filling station for street washing vehicles
- Garage No.4 at Me Tri will need a new parking area, a workshop and a water filling station for street washing vehicles.

By 2005 the increasing number of vehicles will result in overcrowding at garage facility No.1 and No.2. Therefore, two new garage facilities are proposed:

- One facility (referred to as Garage No.5 in the garage allocation table for 2010) located near Hai Ba Trung district for Enterprise No. 3 and
- One facility (referred to as Garage No.6 in the garage allocation table for 2010) near Cau Giay and Ba Dinh districts for Enterprise No.1.

Garage expansions and new garage facilities should be sized now with ample spare capacity for future needs. The present cost of providing spare capacity is relatively small compared to the difficulties and costs of acquiring new sites in the future. Since there is always some uncertainty in any projection it is recommended that facilities be sized for a minimum of 120 vehicles.

Allocation Of Garages On A District Basis – Year 2005

YEAR 2005							
Garage No. (vehicle capacity)	Ba Dinh	Cau Giay	Hoan Kiem	Hai Ba Trung	Dong Da	Thanh Xuan	Tay Ho
Garage No.1 (80)							Enterprise No.5 (28)
Garage No.2 (60)			Enterprise No.2 (33)				
Garage No.3 (15)	Transport Unit No.3 (Septage trucks and bucket latrines only)						
Garage No.4					Enterprise No.4 (95)		
New Garage Facilities	Enterprise No.1 (70)			Enterprise No.3 (67)			

By 2010 the number of vehicles required by each enterprise will have increased but capacity at garage facilities will be adequate if the proposed new facilities are constructed.

Allocation Of Garages On A District Basis – Year 2010

YEAR 2010							
Garage No. (vehicle capacity)	Ba Dinh	Cau Giay	Hoan Kiem	Hai Ba Trung	Dong Da	Thanh Xuan	Tay Ho
Garage No.1 (80)							Enterprise No.5 (41)
Garage No.2 (60)			Enterprise No.2 (40)				
Garage No.3 (15)	Transport Unit No.3 (Septage trucks and bucket latrines only)						
Garage No.4 (120)					Enterprise No.4 (77)		
Garage No.5 (120)				Enterprise No.3 (77)			
Garage No.6 (120)	Enterprise No.1 (93)						

7) Physical requirements for garage facilities

Each existing garage will need to be upgraded with the following facilities:

- Paved parking surface
- Water filling station for street washing vehicles (except garage no.1 which already has a filling station)
- Bulk fuel dispensing station with fuel storage tank
- Mechanical maintenance workshop for daily preventive maintenance and minor repairs

Two new garage sites are required. The sites should be sized to meet the future number of vehicles. The typical space and equipment requirements for

garage facility serving 120 vehicles are outlined below:

Physical requirements for typical garage

Function	Remarks	Required Space
Parking area	- Space for up to 120 vehicles: collection, septage & street washing. - Roadways between & around parking spaces	$30m^2$ x 120 = 3600 m^2 2000 m^2
Water filling station for street washing vehicles	- Water supply: groundwater or piped from water supply network. - Water reservoir for gravity feed: 20,000 liters. - Sufficient space to fill up to 2 trucks at the same time.	$120m^2$
Bulk fuel station	- Above ground fuel reservoir with containment curb.	$120m^2$
Workshop building	- Three maintenance bays, one bay with hydraulic lift. - Tool and machine shop equipped for daily maintenance and minor repair of vehicles. - Washroom and lockers for mechanics	70 m^2 x 3 = 210 m^2 100 m^2 50 m^2
Vehicle washing area	- Water supply and three bays for washing vehicles	72 m^2 x 2 = 144 m^2
Administrative building	- Office - Locker rooms for drivers - Washrooms & Common space - Storage	100 m^2 150 m^2 100 m^2 50 m^2
Land space	- Set back and landscape buffer	1650 m^2
	Total	Approx. 10,000 m^2

A site plan showing the arrangement for a typical garage facility is presented in Figure 6.5.4. A minimum of approximately 1 hectare will be required for each new garage site. Maintenance workshops at existing and new garages will need to be equipped for daily maintenance and minor repair of vehicles such as:

- Oil changes and lubrication
- Battery charging
- Tire maintenance and replacement
- Wheel balancing
- Minor repairs to chassis

A list of equipment and tools required to support these maintenance activities is presented in Table 6.5.13. Cost estimates for constructing and upgrading garage facilities are presented in Table 6.5.14 and Table 6.5.15 and summarized in the following table:

Cost of Garage Facilities

(Unit: US$)

Cost Item	Garage Facility						Total
	No.1	No.2	No.3	No.4	No.5	No.6	
	Upgrade	Upgrade	No change	Expand existing	New site	New site	
Direct Cost	225,000	275,000	0	570,000	570,000	570,000	2,210,000
Land acquisition	0	0	0	0	250,000	250,000	500,000
Eng. 15%	33,750	41,250	0	85,500	85,500	85,500	331,500
Admin. costs 3%	6,750	8,250	0	17,100	17,100	17,100	66,300
Subtotal	265,250	324,500	0	672,600	922,600	922,600	3,107,550
Contingency 10%	26,525	32,450	0	67,260	92,260	92,260	310, 755
Total cost	291,775	356,950	0	739,860	1,014,860	1,014,860	3,418,305

8) Central maintenance facility

The Mechanical Enterprise is responsible for managing the maintenance of all fleet vehicles. Daily servicing and minor repairs are carried out at transportation garage facilities. Planned 6 month, 5,000 km maintenance as well as major repairs and refurbishing is carried out by the Mechanical Enterprise at its workshop and production facilities located at Don Da district, De La Thanh Street.

The central workshop of the Mechanical Enterprise is cramped for space and lacks the equipment, tools and staging areas required for major overhauls. This limits the capacity to process more than a few vehicles at any one time causing delays in scheduled maintenance.

URENCO plans to construct a new maintenance workshop and mechanical fabrication plant and has identified a 2 hectare site in Minh Khai Commune, Tu Liem District. URENCO has not provided a plan for the facility but estimates that the construction cost for the buildings and parking areas will be around 5,383 million VND (385,000 USD). URENCO has limited financial resources and has requested funding assistance to supply tools and equipment for the workshop.

The workshop will be divided into three functional sections:

Section 1: Vehicle maintenance

- level 1 maintenance (major overhauls): 10 vehicles per year
- level 2 maintenance (annual servicing): 400 vehicles per year
- other repairs and minor maintenance: 2600 vehicles per year

Section 2: Repair to vehicles, machines and specialized equipment

- repair to vehicles: 56 vehicles per year
- repair to heavy machines: 7 pieces per year
- repair to specialized facilities: 28 units per year
- Section 3: Mechanical Manufacturing
- fabrication of garbage collection hand carts: 2000 units per year
- renewal of collection trucks (bodies/engines): 35 vehicles per year

The typical space and functional requirements for the maintenance workshop is illustrated in Figure 6.5.5. The total space required for the vehicle maintenance functions only is approximately 1000 m^2. Additional space of approximately 1000 m^2 is required for the mechanical fabrication section and approximately 1500 m^2 should be allocated for vehicle parking, washing, fuelling and maneuvering.

Equipment and tools that are required to support vehicle maintenance activities are presented in Table 6.5.16. The total cost for outfitting the maintenance workshop is approximately 1.6 million USD.

9) Field Service Equipment

URENCO presently has no means of servicing vehicles in the field when they breakdown. Many vehicles that breakdown could be back in service within hours if they could be repaired on site. At present vehicles are towed back to the central maintenance facility for trouble shooting and repair. This is a slow and inefficient process. Vehicles can be out of service for a day or more even though the problem may be minor.

A mobile field service workshop would greatly improve vehicle availability. A variety of fully equipped, mobile mechanical workshops are available ranging from small aluminum cube vans to larger trailer units. A budget cost of 175,000 USD is recommended for a cube van outfitted with tools and equipment for emergency repairs.

10) Site Locations of Solid Waste Management Facilities

Figure 6.5.8 shows site locations of the solid waste management facilities including workshop and garages to be upgraded or newly constructed.

6.5.4 Municipal Waste Disposal Plan

(1) Disposal Options

1) Major Options

There are two basic options with respect to solid waste disposal.

- Option A: Disposal without intermediate treatment
- Option B: Disposal with intermediate treatment

Option A has the following suboptions:

- Sanitary landfill (of different levels)
- Open dumping landfill

Major options of the intermediate treatment are as follows:

- Incineration
- Composting

It should be noted that there are no disposal options that do not require the landfill. Application of any intermediate treatment will require final disposal (landfill) for disposal of residues such as incineration ash or compost residue. Therefore, Option B should be expressed as follows:

- Option B1: Incineration + landfill of incineration ash
- Option B2: Composting + landfill of compost residue

2) Basic Characteristics of the Disposal Options

Characteristics of each option will be clarified in terms of the following aspects:

- Primary and secondary objectives
- Environmental pollution
- Land requirement
- Flexibility with respect to daily waste receiving capacity
- Planned and actual useful period of facilities
- Necessary conditions in terms of waste quality
- Cost

(a) Primary and Secondary Objectives

Though the above listed disposal options are helpful for waste disposal, primary objectives of each option is different each other.

The primary objective of landfill is to dispose of solid waste. In some cases, creation of land out of water body (lakes, seashore) can be the secondary objective or benefit.

Primary objective of the incineration is the volume reduction of waste that is to be landfilled, and the stabilization of chemical characteristics of waste. Incinerators reduce solid waste volume after incineration. Typically, incineration ash is 20 % of original solid waste in terms of weight and 10 % in terms of volume.

Primary objective of the composting is production of compost product, and reduction of waste is the secondary benefit. Waste amount is reduced to about 40 -60 % in terms of weight through normal composting process. Therefore, in principle, the feasibility of composting should be studied in terms of profitability of the composting business based on conditions of demand and supply.

Primary and Secondary Objectives of Each Option

	Landfill	Incineration	Composting
1. Primary objective	Disposal of solid waste	Reduction of waste to be landfilled, and chemical stabilization of waste	Production of compost product
2. Secondary objective	In some cases, creation of land out of swamp or pond, for example	Utilization of heat or power generation	Volume reduction of waste to be landfilled

(b) Environmental Pollution

Intermediate treatment of solid waste or final disposal (landfill) can be sources of pollution.

Landfill:

Open dumping of waste causes the following pollution:

- contamination of ground water or surface water with leachate (dirty water generated from waste deposit)
- scattering of solid waste around sites
- odor
- fire and smoke
- rodents and flies

Risks of this environmental pollution can be minimized with application of the sanitary landfill. Idea of the sanitary landfill is to isolate solid waste with retaining structure (embankment), bottom liner (either clay or artificial liner) and cover soil. Generation of fires, smoke, odor, rodents and flies can be substantially prevented by application of cover soil and fences. Leachate problems can be substantially eliminated by leachate collection and treatment system.

Incineration:

Emissions from waste incinerators can be sources of pollution. Major emissions are CO_2, SOx, NOx, dioxin, mercury and some other heavy metals, of which dioxin is of the most serious concern. Dioxin affects health of people, and causes probability of cancer and other diseases to increase. The international trend is to make the dioxin emission standard stricter.

Remarks: Measures for controlling dioxin include control of types of waste accepted, control of combustion conditions, emission control, treatment of the incineration ash for stabilization.

Other emissions may be controlled below emission standards with application of modern technology.

Recent studies show that dioxin is found in and around landfill sites that receive incineration ash. There will be future studies to analyze where and how dioxin contained in incineration ash goes. Depending on the findings of the studies, some more measures may be required to avoid further contamination with dioxin contained in incineration ash that is landfilled.

Remarks: Bad smell is generated from the waste pit of an incinerator. This smell can be controlled by providing air curtains and other measures. Leachate (wastewater) is generated from the waste pit and also from process of treatment of flue gas and incineration ash. It is possible to control the wastewater with treatment facility and recycle it within the site.

Composting:

Major public nuisance related to compost production is odor. There are some compost plants that were closed due to complaints of local residents living near the plants. Odor problems can be minimized through selection of location of the plants and process improvement, which, however, leads to higher costs.

Both a composting plant and incinerator are normally equipped with rotating machines of large size for sending air or other purposes. Such machines generate noise and sometimes vibration. Noise and vibration prevention measures are required.

Public Nuisance Caused by Waste Collection Trucks:

Trucks are used to transport solid waste is transported to landfill site, incinerator and composting plant. In some cases, such trucks cause public nuisance such as noise, vibration, traffic congestion, and traffic accidents. Degree of these nuisances primarily depends on location of the facility and

amount of waste transported, irrespective of type of facility.

Acceptability of Facilities by Local Residents:

Construction of any solid waste management facilities encounters opposition by local residents. Project proponents must go through appropriate administrative procedures including EIA, public hearing, compensation scheme, monitoring. Disclosure of the project information and dialogue with local residents are essential.

Environmental Impacts Caused during Construction of Facilities:

Regardless of types of solid waste management facilities, the construction activities cause environmental pollution such as noise, vibration, traffic congestion, gas emission of dump trucks, etc. As the facility construction takes a few years, it is important to take measures to minimize such pollution.

Conclusion:

There is no internationally accepted scientific theory that supports that the waste incineration is more environmentally friendly than the sanitary landfill. In recent years, problems of dioxin discharged from waste incinerators receive much more attention than problems of leachate generated in landfill sites.

(c) Land Requirement

Land requirement for each option is estimated assuming that daily disposal amount of waste is 1,000 ton, which is same as the current level of waste collection of URENCO in Hanoi.

The landfill is a land intensive disposal method. It is estimated that 2 ha of land is required per year.

The incineration option requires disposal of incineration ash at a sanitary landfill. Land requirement for disposal of incineration ash is estimated to be about 0.3 ha/year, which is 15 % of that of the sanitary landfill option. An incineration plant with capacity of 1,000 ton/day would require a site of about 5 ha.

The compost option will require disposal of compost rejects or residue at a sanitary landfill. Land requirement for disposal of compost rejects is estimated to be 0.9 – 1.2ha/year. A compost plant with waste receiving capacity of 1,000 ton/day would require 20 ha at least.

Land Requirement

	Sanitary Landfill	Incineration & Landfill of Incineration Ash	Composting & Landfill of Compost Residue
Assumption & conditions	- Incoming waste: 1,000 ton/day - Land requirement for incineration ash: 15% of original waste for compost residue: 45-60% of incoming waste (the ratios depends on level of recovery of useful materials at compost plant)		
Land requirement	2 ha per year (see comment below)	5 ha for incinerator, & 0.3 ha per year for landfill of incineration ash	20 ha for composting facility, & 0.9 - 1.2 ha per year for landfill of compost residue

Long Term Consideration:

In the long term, land requirement for landfill would be smaller than that indicated above because it is possible to use post-closure landfill sites for other purposes such as agriculture, amusement and amenity (parks and sport fields), industrial, commercial and housing. It takes 5 – 30 years of time before post-closure sites can be used.

Since long time ago, people used some land as waste dumping places. However, most people even do not know the fact that some particular lands were used as waste dumping places long time ago if they are old enough, say 50 years ago or older. Any land has a history of land use that changed over long period. Use of a land for landfill is just transient in long history. A period of 50 years may be too long for ordinary city development planning. However, land use cycle of such a long period should be taken into consideration from the perspective of long-term sustainable development.

(d) Flexibility with respect to Daily Waste Receiving Capacity

A big difference between the landfill and intermediate treatment options such as incineration or composting is that landfill sites can receive any amount of waste each day, while the daily maximum waste-receiving amount of an intermediate treatment facility is limited by the design capacity. Thus, the landfill is flexible in terms of daily waste receiving capacity.

Daily Waste Receiving Capacity

	Sanitary Landfill	Incineration	Composting
Maximum daily receiving amount	Almost no restriction. A landfill site can practically receive any amount of waste each day.	Restricted by design capacity.	Restricted by design capacity.

(c) Planned and Actual Useful Period of Facilities

There is a tendency that total waste amount received at a landfill site turns out to be much more than original design capacity due to land settlement due to waste consolidation. As consequence, actual use period of landfill sites tend to be longer than the period initially planned. The longer period in turn leads to more decomposition of waste, which then contributes to making the useful period even longer. In reality, it often happens that use period of landfill sites is longer than planned due to waste burning on site and less use of cover materials though they are not advisable at all.

On the other hand, total waste amount received by intermediate treatment facilities tends to be less than the amount planned due to technical/operational and other problems.

Overall Performance (Utilization) throughout Use Period

	Sanitary Landfill	Incineration	Composting
Planned and actual useful period of facility	There is a strong tendency that total amount of waste received throughout the useful period turns out to be more than the design capacity, and therefore, the actual useful period is longer.	There is tendency that actual incineration amount turns out to be less than the design capacity due to technical/ operational problems as well as deterioration of the facility capacity.	Globally, most compost plants using municipal solid waste turn out to be infeasible and failure, and closed earlier than planned.

Case of Municipal Waste Incinerator in Surabaya, Indonesia

Operation and maintenance of a modern incinerator require high level of operation skill and experience, without which mechanical and other failures occur. In case of Surabaya, Indonesia, the actual incineration amount turned out to be about 150 ton/day, 75% of the design capacity (200 ton/day) during one year even after a few years of operation.

Under normal condition, an incinerator typically operates 10.5 months (320 days) per year; the remaining 1.5 months of suspension is needed per year for maintenance. Therefore, in case of Surabaya, actual waste amount incinerated turned out to be 131.5 ton/day on average, 66% of the design capacity (Calculation: 150 ton/day x 320 days/year ÷ 365 days = 131.5 ton/day 131.5 ton/day ÷ 200 ton/day = 66%)

For Surabaya, an incinerator with capacity of 300 ton/day was required to incinerate 200 ton of solid waste constantly every day throughout year. It is considered that this situation is likely to happen in other developing countries including Vietnam.

(f) Necessary Conditions in terms of Waste Quality, Income and Market Conditions

Waste Calorie:

Waste quality and income of the citizens are important conditions that seriously affect feasibility of incineration and composting. Minimum calorie of waste required for self-burning of waste is at least 1,000 kcal/kg in terms of lower calorific value (LCV). In general, incineration is not applied to solid waste with LCV less than 1,000 kcal/kg. Exceptions are hospital waste and some other toxic waste. Incineration is commonly applied to such types of waste to make the waste harmless.

At present, corresponding calorie of Hanoi waste is estimated to be 715 kcal/kg, so it is not suitable for incineration.

It is possible to incinerate any solid waste of inadequate calorie by using fuel (heavy oil). However, it will cost much.

Income:

From an economic point of view, per capita average income of $5,000/year or thereabouts is needed in order not to cause excessive financial burden. Application of sanitary landfill requires a minimum per capita income of about $600/year.

It should be noted that the above-shown minimum calorie and income are the necessary conditions for application of incineration, but not adequate conditions. Even if these conditions are met, incineration of municipal waste may not be necessary if landfill sites are available.

Market Conditions:

Feasibility of composting depends primarily on market conditions for compost. Adequate and constant demand for compost product must exist within area of about 30 km from the compost plant. See Item 4) Technical Comment for further discussion.

Necessary Conditions to be Met

	Open dumping	Sanitary landfill (S/L)	Incineration + S/L of ash	Composting + S/L of residue
1. Minimum waste calorie (lower calorific value)	none	none	For self burning: 1,000kcal/kg For feasible power generation: 1,500kcal/kg	None
2. Organic content	None	None	None (Some organic waste is needed though to be combustible.)	Organic content: more than 50%, Certain CN ratio
3. Financial conditions (minimum per capita income)	None	$600/capita/ year	$5,000/capita/ year	None if composting business itself is successful
4. Market conditions	None	None	None (There should be certain demand for electricity if power generation is to be feasible.)	Adequate and constant demand for compost product within 30 km from the compost facility.

Minimum per capita income shown above were estimated based on the following conditions:

a. Ratio of solid waste management cost to Gross Regional Products should not exceed 1%.
b. Cost of treatment and disposal should not exceed 33% of the total solid waste management including waste collection and transport. In general, this ratio is 10% or less in developing countries.
c. Waste collection amount is assumed to be 780 gram/capita/day, which is similar to that of Hanoi.
d. Cost of options: same assumptions are used in the previous table.

(f) Cost

a) Gross Cost

The landfill is the least cost disposal method. Typical unit costs of disposal options for Vietnam are estimated as follows:

- Open dumping: $0.5 - 1/ton
- Sanitary landfill with artificial lining and leachate treatment: $5 - $7/ton
- Incineration + sanitary landfill of incineration ash: $58/ton
- Composting: $20/ton (gross cost per ton of waste received at compost plant)

Details are shown in the table below.

b) Compost Sales and Net Cost of Composting Option

The compost option brings about revenues from compost sales. Assuming compost is produced as planned for the Spanish ODA financed compost project, and sold at prevailing price ($70/ton of product), the net cost would be reduced from $20.2/ton of waste to $1.6/ton of waste, which is lower than the unit cost of the sanitary landfill planned in Nam Son. It is estimated that net disposal cost with the compost option would be equivalent to the cost of the sanitary landfill ($7/ton) if actual compost sales turn out to be 67% of the planned revenue. Larger the production capacity of the compost plant, the lower the probability of achieving this 67%.

Composting business in Hanoi may be feasible on a small scale. However, judging from the current market conditions, it is unlikely that large quantity of compost (for example 100ton/day of compost) would be constantly sold at constant price.

Case of Bangkok: Since the 1960s, Bangkok city (Bangkok Metropolitan Administration: BMA) has applied a large scale composting with design waste receiving capacity of about 1,000 ton/day. According to the JICA Study conducted in 1990, the total cost of production was several times larger than the total benefits (compost sales plus theoretical benefit arising from saving of landfill cost derived from waste volume reduction through composting). In 1991, BMA decided to purchase a new composting plant of the same scale to replace the old one. According to BMA staff, this decision was made politically in spite of the fact that all BMA technical staff was against this decision.

Comment on recovery of useful materials at compost plants: During the pretreatment of waste (removal of unsuitable materials) that is a part of production process, it is possible to recover some useful materials. However, a difficulty lies in the sales of recovered materials, which is subject to the market conditions. In general, materials recovered from waste are lower in quality and prices than those collected directly from households or factories by junk buyers. In some cases, costs of recovery of useful materials at compost plants exceed sales revenue of recovered materials.

c) Power Generation and Net Cost of Incineration Option:

A sub-option of the incineration option is the incineration with power generation. In theory, benefit of the power generation contributes to reducing the incineration cost by about 10%. In reality, however, it would be extremely difficult for Hanoi to recover the additional cost (about 20% of the incineration cost) for installation and operation/maintenance costs of power

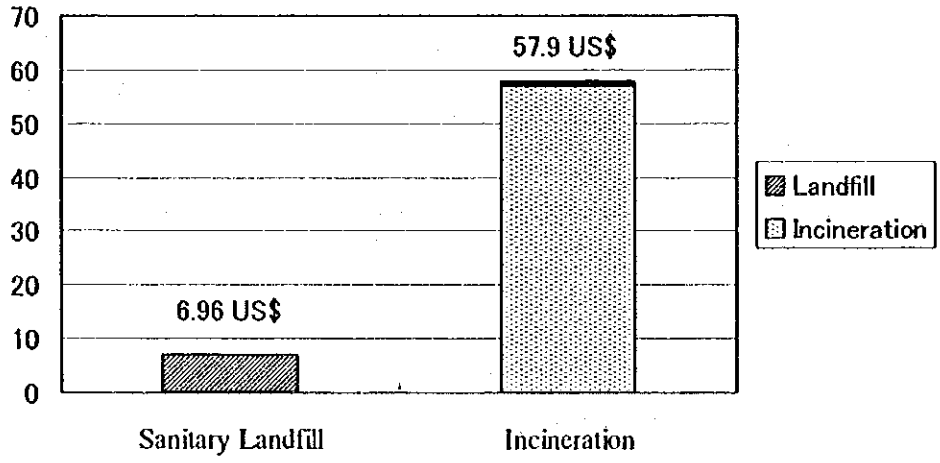
generation. In the 40 years of the incineration history in Japan, it is in only recent years that the additional investments in power generation turned out to be economically feasible. See Item 4) Technical Comments for feasible conditions of the power generation.

In Europe and Japan, typical unit cost of incineration of municipal waste ranges from $100 to $200/ton. In Japan, the most successful power generation from waste incineration contributes to reducing the incineration cost by about 10% or so. See the Note 4 of the table below.

d) Difference in Costs between Sanitary Landfill and Incineration Option

i) Difference in Unit Costs

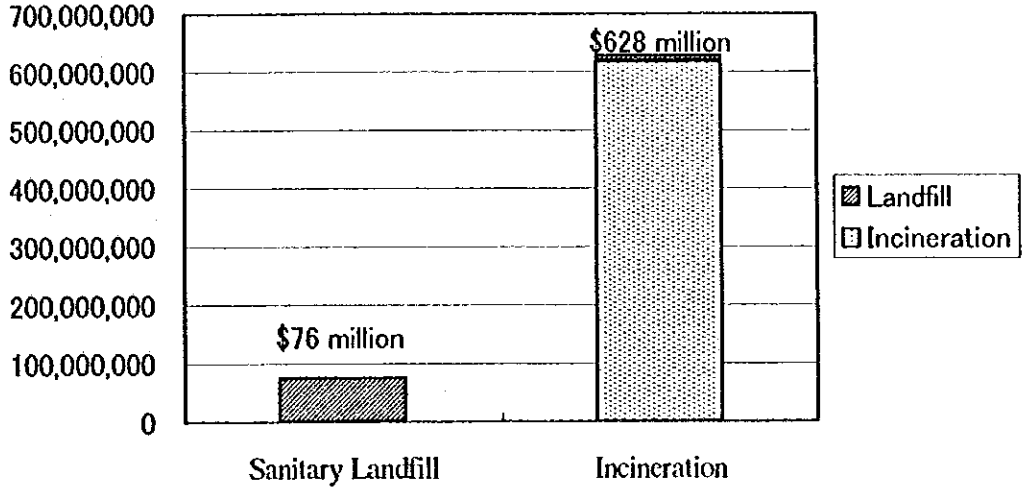
The incineration option is more than 8 times more costly than the sanitary landfill option as illustrated below.



Comparison of Unit Costs of Sanitary Landfill and Incineration

ii) Difference in Total Costs through the Use Period

Total cost of Nam Son Phase 2 landfill plan including cost of construction and operation/maintenance for the whole planned period from the beginning of 2004 till the beginning of 2018 is estimated to be $75.5 million approximately. It is estimated that $628.4 million is required if Nam Son Phase 2 landfill plan is fully replaced by the incineration option during the same period. The cost difference is about $553 million.



Comparison of Total Costs of Sanitary Landfill and Incineration During the Whole Operation Period 2004 - 2018

Calculation:

A. Total cost of the Nam Son Phase 2 Sanitary Landfill

= Unit cost ($6.96/ton) x total amount of waste disposed of during 2004-2018 (10,852,554 ton) = $75,533,775

B. Total cost of the case where all waste is incinerated, and incineration ash is disposed of by the sanitary landfill

= Unit cost ($56.9/ton + $1/ton) x total amount of waste disposed of during 2004-2018 = $57.9/ton x 10,852,554 ton = $628,362,877

Difference = B – A = $628,362,877 - $75,533,775 = $552,829,101

Difference per hector of land: $552,829,101 / 60ha of landfill area = $9,213,818/ha

Remark 1: Maximum Compensation That Could be Paid

This cost difference implies that Nam Son landfill plan is still more economical than the incineration option even if HPC has to pay $552 million to local residents for relocation and compensation. Since Nam Son Phase Landfill site has about 60 ha, unit cost of relocation and compensation per hector is calculated as 9.2 million/hector.

On the other hand, according to HPC, it has agreed with local residents to pay them a total of $3 million (42 billion Vietnamese Dong) approximately to acquire the planned land for Nam Son Solid Waste Treatment Complex Site, which includes Phase 1 Landfill (13 ha), Phase 2 Landfill (60 ha) and some other sites for composting, etc.

Remark 2: Siting a Landfill site at Distant Place

In future, there might arise a situation where HPC cannot acquire landfill sites in HPC jurisdiction area, but can acquire landfill sites outside the jurisdiction area. In this case, distance of waste transport to landfill sites may be longer, and the transport cost would be higher. In this case, cost of transportation must be taken into consideration in evaluating disposal options. A relevant cost indicator is the sum of A and B, where A is transport cost, and B is disposal option cost. An option with lower sum of A + B is more economical. Using the cost information about the cost of transport from the planned Dong Ngac transfer station to Nam Son and certain assumptions, it is estimated that the landfill option is still economical if the landfill site can be located within 300 km from Dong Ngac. See calculation below.

A. Incineration Option

a: Transport cost from Dong Ngac to Nam Son = $3/ton

(Source of information: Pre-feasibility study on the Transfer System by the JICA Study Team)

b: Incineration option cost = $57.9/ton

A = a + b = $3/ton + $57.9 = $60.9/ton

B. Case of Landfill in Distant Place

c: Transport cost from Dong Ngac to Nam Son = $x/ton

d: Landfill cost: $6.96/ton

B = c + d = $x/ton + $6.96/ton

A will be equal to B when x = $53.94 ($60.9 - $6.96) per ton

The calculated transport cost of $53.94/ton is 18 times higher than $3/ton, the transport cost from Dong Ngac to Nam Son. Assuming that the transport cost is proportional to the distance, and considering the fact that distance between Dong Ngac to Nam Son is 37.5km, $53.94/ton of transport cost implies that the transport distance would be 674 km (37.5 km x 18 times).

Assuming that the coefficient between the cost of waste transport and the transport distance is 0.5 to be on safe side, the maximum distance of landfill site is estimated to be about 300 km (674 km x 1/2 = 337 km)

e) Annual Cost for Each Option

Annual costs for respective options are estimated as follows assuming that each option will dispose of 1,000 ton/day of waste. Costs include those of construction (in terms of annual depreciation) and operation/maintenance.

- Open dumping: $182,500 - $365,000/year
- Sanitary landfill with artificial lining and leachate treatment: $1,825,000 - $2,555,000/year (Case of the Planned Nam Son Phase 2 Landfill)
- Incineration + Sanitary landfill of incineration ash:
  a. With successful power generation: $19,089,500/year

     (This is the case where calorie of Hanoi waste (LCV) would increase to 1,500 kcal/kg or more.)

  b. No power generation:$21,170,000/year

     (This is the case where no power generation facility is installed to the waste incineration.)

  c. With unsuccessful power generation: $23,250,500/year

     (This is the case where power generation facility is installed under the current waste conditions, which will then lead to the situation where sales revenue of electricity would be only 50% of the additional investment in the power generation.)

     (See Note 4 of the table below for further explanation.)
- Composting + Sanitary landfill of compost residue
  a. Case where compost product is sold fully as planned: $328,500/year
  b. Case where compost sales turned out to be 67% of the planned sales: $2,555,000/year (same as the cost of the sanitary landfill)
  c. Case where compost product is not sold at all: $5,438,500/year

The table below summarizes the cost information discussed in this section.

Cost Comparison of Disposal Options for Hanoi

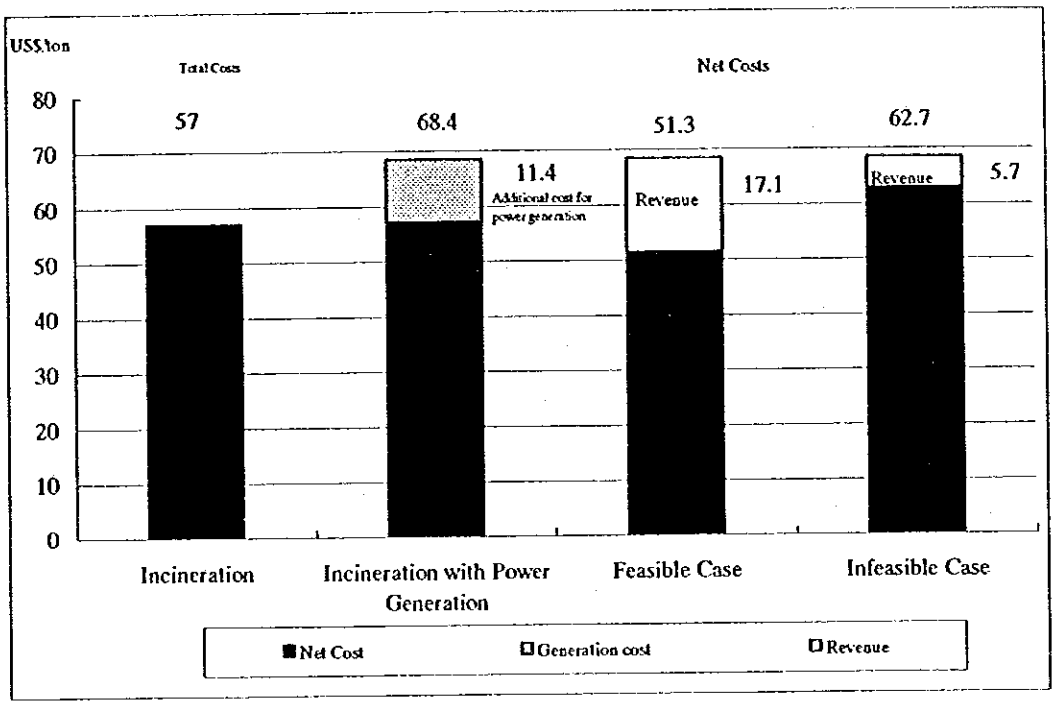
	Open dumping	Sanitary landfill (S/L)	Incineration + S/L of ash	Composting + S/L of residue
1. Unit cost of intermediate treatment	$0/ton	$0/ton	$57/ton	$16/ton
2. Unit cost of disposal of waste or residue	$0.5 - $1/ton	$5 - $7/ton	$1/ton ($7/ton x 15%) (ash ratio)	$3.5/ton ($7/ton x 50%) (residue ratio)
3. Total unit cost (1 + 2)	$0.5 - $1/ton	$5 - $7/ton	$58/ton	$19.5/ton
4. Net revenue from sales of electricity or compost	$0/ton	$0/ton	(-)$5.7/ton to (+) $5.7/ton $	$4.6/ton -$18.6/ton
5. Net cost (3 – 4)	$0.5 - $1/ton	$5 - $7/ton	$52.3/ton -$63.7/ton	$0.9/ton -$14.9/ton
6. Annual cost assuming incoming waste = 1000 t/day	$182,500 – $365,000/ year	$1,825,000 – $2,555,000/ year	$19,089,500 – $23,250,500/ year	$328,500 – $5,438,500/ year
7. Cost Index	7 to 14	100 ($2,555,000 is used as base)	708 to 912	13 to 213 (100 if total compost sales revenue is 67% of planned sales.)

Information source:
1. Cost of sanitary landfill: Pre-feasibility study on Nam Son Phase 2 Landfill, JICA Study Team
2. Cost of incineration: Feasibility study on waste-to-energy recycling facility using garbage and local coal in Hanoi for environment protection, September 1998. Main assumptions and conditions used for cost estimation are summarized in Note 6 below.

Notes:
1. It is assumed that the incineration ash to be landfill is 15% of the input waste in terms of weight. Cost of the sanitary landfill of the ash is proportional to amount of incineration ash.
2. Sales revenue of electricity

Additional investment in a power generation facility (to be attached to a waste incinerator) would typically require 20% of the cost of construction of an incineration plant. Assuming that operation and maintenance (O&M) cost of power generation is also 20% of the O&M cost of incinerator, unit cost of power generation is estimated to be $11.4/ton, 20% of the incineration cost ($57/ton). Sales revenue very much depends on conditions of purchase of electricity by power company, as well as amount and quality of electricity generated, which depends on conditions of waste incineration. The revenue may or may not exceed the cost of power generation. It is arbitrary assumed that sale revenue may range from 50% ($5.7/ton) to 150% ($17.1/ton) of the

cost of power generation for Hanoi. With these assumptions, net profit from power generation is estimated to range from minus \$5.7 (\$5.7 - \$11.4) to plus \$5.7/ton (\$17.1 – \$11.4) of waste incinerated. Further explanation on the power generation is shown in Item 4) Further Comments on Composting and Incineration.



Feasible and Infeasible Cases of Power Generation through Incineration

1. Cost of compost:

Assumptions:

Planning information on the compost plant to be financed by Spanish ODA is used as base.

a. Initial investment \$4,000,000
b. Useful period of the facility: 10 years
c. Operation & maintenance: \$ 400,000/year
d. Incoming waste: 50,000 ton/year
e. Production of compost: 13,260 ton/year (26.52% of waste in terms of weight)
f. Residue to be disposed of by landfill: 25,000 ton/year
g. Cost of landfill of the residue: \$7/ton of residue
h. Price of compost: \$70/ton of product

Calculations:

a. Production cost: Annual depreciation of investment ($4,000,000 ÷ 10 years + Operation & maintenance $400,000 = $800,000/year
b. Cost of landfill of compost residue: $7/ton x 25,000 ton/year = $175,000/year
c. Total cost of compost production including cost of disposal of compost residue: Production cost per ton of incoming waste: $800,000 + $175,000 = $975,000/year
d. Unit cost of production including cost of disposal of compost residue: $975,000/year ÷ 50,000 ton/year = $19.5/ton
e. Total revenue from compost sales: $70/ton x 13,260 ton/year = $928,200/year when sales is realized at 100% as planned
f. Revenue per ton of incoming waste: $928,200/year ÷ 50,000 ton/year = $18.56/ton when sales is realized at 100% as planned ($4.6/ton if sales revenue is 25%.)

6. Major Assumptions on specifications of the incinerator used for cost estimation

- Incineration capacity: 330 tons per day
- Incineration efficiency: 90% = 330 x 90% = 297 tons per day
- Operation days: 325 days per year
- Operation life: 20 years
- Power generation equipment: none
- Residual ash generation: 15% of input waste = 297 t/d x 15% = 45 tons per day
- Total investment cost: 68,300,000 US$ (= 7,850 million JPY, 115 JPY/US$)
- Operation & Maintenance: 2,080,000 US$/y (= 239.5 million JPY/y) = 41,600,000 US$ for 20 years
- Waste amount to be incinerated: 297 t/d x 325 d/y x 20 years = 1,930,500 tons
- Unit Cost for incinerating = 56.9 US$/waste-ton
- Unit Cost for dumping the residue = $6.96 x 15% = 1.0 US$/waste-ton
- Total Unit Cost for incineration method = $56.9 + $1.0 = $57.9 / waste-ton

3) Evaluation of Disposal Options

(a) Evaluation Criteria and Methodology

It is generally considered that the least cost method is the most appropriate method for evaluation of disposal options and many other environmental protection measures. The least cost method sets out both environmental and economic criteria:

- Environmental criteria (environmental soundness)
- Economic criteria (cost-effectiveness and affordability)

Evaluation methodology is as follows:

1. evaluate disposal options based on environmental criteria, and eliminate options that are not acceptable
2. estimate costs of each options, and select the least cost options
3. evaluate financial affordability of implementing agency (HPC)

(b) Evaluation

a) Environment-soundness

As has been clarified in the previous section, the open dumping causes significant environment pollution to the surrounding environment, and therefore is not acceptable based on environmental criteria. There are environment pollution risks associated with other options as well. Types of environmental risks are different depending on options as explained in the previous section. However, environment pollution risks associated with the sanitary landfill, incineration and composting are considered low and therefore acceptable.

There is no scientific theory that supports incineration is more environmentally sound than the sanitary landfill or visa-versa.

Evaluation of Disposal Options in Terms of Environment-soundness

	Open dumping	Sanitary landfill (S/L)	Incineration + S/L of ash	Composting + S/L of residue
Environment-soundness	Not acceptable	acceptable	acceptable	acceptable

b) Economic Aspects

i) Cost-effectiveness

The best indicator of cost-effectiveness is the unit cost. Unit costs of each option are shown in the previous section. Open dumping is the least cost, however should be rejected as it does not meet the environmental criteria.

Among the options that meet the environmental criteria, the sanitary landfill is the least cost. Its unit costs ranges from US$5 - $7 per ton of waste disposed of.

Unit cost of the incineration option including cost of landfill of incineration ash is US$ 58/ton at minimum for Hanoi. Theoretically, the incineration cost may be reduced by about 10% by power generation at minimum. Cost of power generation would cost about 20% of the incineration cost. Considering waste quality of Hanoi, and other conditions, there is a high risk that the additional investment in power generation would bring about negative profit in Hanoi.

Unit cost of composting option is estimated to be US$20.2/ton including cost of landfill of compost residue. Since this option brings about some sales revenue, the net disposal cost of this option can be reduced. However, based on the prevailing price of compost in Hanoi, and cost information on the Spanish-ODA financed compost project, we consider that it is too risky for HPC to apply the composting option as a major disposal option. Large scale composting should not be applied unless its feasibility is confirmed in the market. See Item4) Technical Comment for more discussion on composting option.

ii) Affordability

Hanoi URENCO's annual expenditure is estimated to be about $7 million in 1999 including depreciation of equipment assessed by the JICA Study Team. This expenditure represents about 0.8% of the estimated Hanoi GRP, and 5% of the estimated HPC's revenue in 1999.

So far, URENCO has been practicing open dumping as major disposal method. The cost of the open dumping were small, i.e., less than 0.03% of the Hanoi GRP. The corresponding ratio will increase to 0.19% with implementation of Nam Son Phase 2 Landfill. Implementation of the incineration option instead of Nam Son Phase 2 Landfill project will cause the ratios to increase to 1.45 – 1.77% of Hanoi GRP, and 13.44 – 16.37% of HPC's revenue. Such high ratios imply too much financial burden on the citizens and HPC as shown in the table below.

In general, in developing countries, costs of solid waste management (SWM) relative to the gross regional product (GRP) range from 0.5% - 1%. Of the total SWM cost, 90% is typically used for waste collection, transport and street sweeping, and the remaining 10% for disposal of waste. It is considered that cost of waste disposal would be too much if the disposal cost exceeds 30% of the total SWM cost.

Assuming an excessive case where 30% of the SWM cost is allowed to spend for waste disposal, and SWM cost can be as large as 1% of the GRP, the maximum disposal cost would reach 0.3% of GRP. Compared to this 0.3%, the above shown range of ratios 1.45 – 1.77% (case of implementation of the incineration option) is extremely high. It would impose serious financial burden on HPC if it has to spend 13 – 16% of its total revenue constantly over some period just for the incineration option.

On the other hand, the sanitary landfill is considered to be affordable in terms of ratios relative to either GRP or HPC revenue.

Ratios of Disposal Option Costs Relative to Hanoi Gross Regional Products and HPC Revenue

	Open dumping	Sanitary landfill (S/L)	Incineration + S/L of ash	Composting + S/L of residue
Annual cost assuming incoming waste = 1000 t/day	$182,500 – $365,000/year	$1,825,000 – $2,555,000/year	$19,089,500 – $23,250,500/year	$328,500 – $5,438,500/year
Ratios of Disposal Cost Relative to Gross Regional Product ($1,314 million in 1999)	0.06 – 0.03%	0.14 – 0.19%	1.45 – 1.77%	0.03 – 0.41%
Ratios of Disposal Cost Relative to HPC's Revenue in 1999 ($142 million)	0.13 -0.26%	1.29 – 1.80%	13.44 – 16.37%	0.23 – 3.83%

c) Conclusion

1. HPC should apply the sanitary landfill, as planned in the pre-feasibility study report, as major disposal option at least until HPC uses up all the area of Nam Son Landfill. It is estimated that Nam Son landfill site will be full in early 2018.
2. Thereafter, HPC should select appropriate future disposal option based on the future socio economic conditions of Hanoi, waste conditions, and conditions of technological changes, which are not predictable at present.
3. HPC should acquire new landfill sites other than Nam Son landfill site as early as possible. The earlier the opening of another landfill site, the longer the useful period of the landfill sites.
4. If the economy of the Hanoi City develop very rapidly, the necessary conditions for introducing waste incineration might be satisfied before the capacity of the Nam Son landfill is full. In that case, the introduction of the waste incineration would have the effect of reducing the waste volume to be disposed of at the Nam Son landfill and thereby extending its life. Considering the necessary lead time for the preparation

including the determination of the type, design, land acquisition, financial arrangement and others, it is recommendable that study should start at the early stage.

Remark

It is very useful to know the timing of introduction of the first incinerators in other countries.

Bangkok:

Bangkok Metropolitan Authority (BMA) of Thailand intended to introduce the first municipal waste incinerator in the early 1980s, when the national GDP per capita was less than $1,000. The first JICA Study on Bangkok Solid Waste Management recommended construction of incinerators with capacity of 600 ton/day. However, BMA's financial conditions did not allow the construction of the planned incinerators. In the early 1990s, JICA conducted another solid waste management study that recommended the construction of an incinerator with capacity of 200 ton/day as a pilot project. However, it was only in 1996 when BMA called for a BOT tender for construction and operation of incinerator and other facility. The tender resulted in failure. National GNP per capita reached $2,960 in 1996 (Source: 1998 World Development Indicator, the World Bank). Currently, it seems that BMA intends to construct incinerators using some ODA funds (loan). According to the same source, the corresponding GNP per capita in Vietnam is $290 in 1996.

Surabaya:

In the early 1990s, Surabaya, the second largest city in Indonesia, introduced an incinerator with capacity of 200 ton/day on BOT base. Annual average of actual incineration amount turned to be about 130 ton/day, two thirds of the planned amount, while the total waste collection amount was about 800 ton/day. In the early 1990s, Surabaya's Gross Regional Product was about $800 per capita. Before the introduction of the incinerator, Surabaya City spent only a few percent of solid waste management budget for waste disposal, and the remaining budget was used for collection/transport of waste and street sweeping After the introduction of the incinerator, Surabaya city spent about 45% of the total solid waste management budget for repayments of construction costs, and operation, which caused a significant financial burden on the city.

Kuala Lumpur:

Since 10 years ago Kuala Lumpur was examining the possibility of introduction of a waste incinerator. However, it is only in recent years that Kuala Lumpur has came to seriously planning on an incinerator. Malaysia's GNP per capita is $4,370 in 1996 (same report, World bank)

Singapore and Hong Kong:

These cities have introduced incinerators in the late 1980s. GNP per capita of these two cities are $30,550 and $24,290, respectively, in 1996 according to the same source.

4) Further Comments on Composting and Incineration

(a) Composting

a) Feasible Conditions of the Composting Business

Appropriateness of compost projects should be primarily examined through feasibility of composting business based on conditions of demand and supply.

As discussed earlier, the primary benefit of the composting is the value of compost product. The secondary benefit is the volume reduction of waste that needs to be landfilled. The primary benefit can be measured in terms of revenue from compost sales. The secondary benefit can be estimated in terms of opportunity cost by the following formula:

(Unit cost of disposal of waste at landfill site) x (amount of waste reduced through composting)

From economic viewpoint, the composting business can be justified if the following condition is met:

$A < B + C$

Where,

A: total cost of compost production

B: Sales revenue of compost (major benefit)

C: Cost of disposal avoided due to volume reduction of waste (minor benefit)

It may be justified that HPC pays owners of the compost plant the above cost C (cost of disposal avoided due to volume reduction of waste) as HPC can enjoy the reduction of cost of landfill.

As discussed earlier, most projects of compost production using general municipal waste have resulted in failure in the world. On the other hand, there are successful cases where compost products are made using agricultural waste. Use of selected waste such as agricultural waste or market waste is important conditions for success of composting.

b) Difficulties in Compost Marketing and Quality Control

Throughout the world, most compost projects with use of municipal solid waste resulted in failure. Major causes of the failure may be summarized as follows:

1. Insufficient and irregular demand for compost products
   Demand for compost is very elastic to prices and quality of compost products. Cost of transport of compost products is a significant portion of cost to users. In general, buyers of compost are restricted within 30 km.
   In some countries, compost of large quantity is used to plantation. Once compost is used to the plantation, users do not need compost for next few years, while the compost is produced every day.
2. Increasing difficulty in quality control of compost product
   i. Changes in Waste Composition:

      The general tendency is that municipal solid waste become less suitable for compost as people's life standard rises. Production of compost requires elimination of metals, and plastics. However, these types of waste increase as life standard rises. As result, control of quality of compost will require more cares and costs. There are many composting plants in the world that terminated operation because those undesirable materials were found in compost products. In India, some years ago, application of compost caused serious health problem. There are some cases where compost product contained tiny glass items.

   ii. Hazardous Elements Found in Compost Product:

      With the upgrading of life standards, hazardous elements, as contained in dry battery cells for example, increase in domestic waste. There are many cases where some hazardous elements were found in compost product. In Romania, there was a case where the compost production was terminated because some chemical toxic elements were found in the compost product.

c) Feasibility of Recovery of Useful Materials at Compost Plant

It should be noted that there exists already a good working market of recyclable materials in and around Hanoi. It is the market conditions that determine amount and price of recyclable materials traded. It is estimated that about 200 ton/day of useful materials are collected by junk buyers in Hanoi. Amount of useful materials collected fromdumpsites is estimated to be less than 10 tons.

According to the Spanish ODA financed compost project plan, 12% of incoming waste are recovered as useful material. It may be possible to sort waste and recover some useful materials. However, the major problem is sales of recovered materials. Materials recovered from waste have lower

quality and value than those collected by junk buyers in Hanoi. Useful materials to be collected from waste at composting plants are low in quality.

It is advised that HPC should pay attention to the market conditions in Hanoi when planning on recovery of useful materials at compost plant.

(b) Incineration

a) Feasible Conditions of Incineration

At present, incineration is not feasible for Hanoi judging from waste quality of Hanoi waste and economic affordability. Incineration may be feasible if and when the necessary and adequate conditions explained earlier are met. Major conditions are summarized:

1. Calorie of waste should reach at least 1,000 kcal/kg for incineration Costs of investments and operation/maintenance in power generation will cause the cost of incineration to increase by 20% at least. In order to recover this additional cost, the calorie of waste must reach 1,500 kcal/kg at minimum.
2. From economic affordability, citizens' income should reach $5,000/person/year. See the remark below.
3. Landfill sites are not available within 300 km from waste collection area or land acquisition cost (relocation and compensation) would exceed $6.8 million/ha in case the site is within HPC area.

b) Toxicity of Incineration Ash

It should be noted that the incineration ash might have higher concentration of toxicity. There are two types of incineration ash, fly ash and bottom ash. Fly ash generated in the furnace and collected at the emission gas treatment process tends to contain higher level of heavy metals. In Canada, the incineration ash is considered as hazardous waste. In Japan, fly ash needs special treatment for stabilization before final disposal at landfill sites. Both types of the incineration ash must be disposed of by sanitary landfill in Japan.

c) Sales of Electricity Generated through Waste Incinerator

Sales of electricity generated through waste incinerator depend on the following two factors:

1. Amount of electricity generated

2. Unit prices of electricity sold

It is important to note that not only electricity generation amount but also unit price of electricity depends on waste incineration conditions. If the amount of electricity generation fluctuates from time to time, buyers of electricity (power companies) consider that such electricity is unreliable and poor in quality. Therefore, they put lower prices for such electricity.

The general tendency is that the lower the caloric of waste (particularly if they are less than 1,000 kcal/kg), the more the fluctuation in electricity generation amount.

In order to reduce fluctuation, it is necessary to set the design waste calorie at high level such as 2,000 kcal/kg. In this case if solid waste of calorie lower than 2,000 kcal/kg are used, fuel (heavy oil) has to be used in order to maintain the design calorie. Given the waste quality condition of Hanoi waste (715kcal/kg), it is estimated that just incineration of one ton of solid waste will require 36 litter of heavy oil that would cost $4.66/ton. With this condition, the generation of electricity through waste incineration would never become feasible.

d) Dioxin

Among the human-made materials, dioxin is the most toxic. It is proved that dioxin would cause cancer, deformity, abnormal reproduction through experiment on animals. Dioxin is colorless, no smell, not dissolved in water but solved in fat, does not react to alkali, acid and other chemical materials. Therefore, dioxin, once emitted to the nature, pollutes soil and water, and would be accumulated in living animals.

In Japan, 80% of dioxin is generated from municipal solid waste incinerators, of which 80% is contained in the incineration ash, and the remaining 20% is emitted to the air.

In Japan, the regulation on dioxin has been strengthened recently. Major methods of control of dioxin include 1) improvement of combustion conditions, 2) quick cooling of flue gas, and 3) collection of dioxin contained in flue gas. Three important control factors are time, temperature and turbulence (called three Ts). An incineration condition with over 800C for at least 2 seconds have to be created to avoid generation of dioxin. Bag-filters and activated carbon are used to eliminate dioxin contained in flue gas.

An incinerator equipped with dioxin control facility is normally 5- 10% more costly than an incinerator without it in terms of both construction cost and operation/maintenance cost.

(c) Slagging Incineration – A New Technology

Description:

The waste slagging is a system to melt incineration ash with high temperature. Incineration ash turns into slag. The waste slagging is useful to reduce amount of treatment residue that need to be disposed of at landfill sites. The slag made from the incineration ash may be used as an auxiliary construction material. There are two main systems for waste slagging.

1) waste incinerator and ash slagging incinerator
2) waste gasification (or pyrolysis) and slagging incinerator

The former consists of the two furnaces; one for incinerating waste, and the other for incinerating (melting) the incineration ash into slags with high temperature of 1200~2000°C by using oil, electricity or coax. This system will require much energy, and very high cost for operation and maintenance. If a waste incineration capacity is over 300 ton/day and is equipped with power generation facility, an electric furnace would be applied for slagging of the ash. The electric furnace uses electricity generated by the waste incinerator.

In the latter system, a part of solid waste will be turned into combustion gas through gasification and decomposition with heat, and the combustion gas will be used to incinerate and change the waste into slags.

Cost:

In Japan, the former system is 10 – 30% more costly than the ordinary waste incinerator. The latter system is about 10% lower than the former system. This system is still in the experimental stage, through which risks need to be assessed in terms of safety, and operation /maintenance.

Applicability for Hanoi:

At present, slagging incineration system is not applicable to Hanoi due tothe following reasons:

a. Slagging incineration system is very costly: more costly than the ordinary incineration.
b. Slagging incineration system with gasification require a minimum, waste calorie of 1,500 kcal/kg, preferably 2,000 kcal/kg, while the calorie of Hanoi waste is less than 800 kcal/kg.

5) Strategy for Waste Incineration in Hanoi

With respect to the introduction of waste incinerators, the following strategy is proposed.

(a) Timing for Introduction of Waste Incinerator

It is advisable for HPC to consider introduction of incinerators when the following conditions are met or likely to be met soon.

a) Technical Conditions

i. For Incineration:

Calorie of waste must reach at least 1,000 kcal/kg that is minimum calorie required for self-burning. Calorie of waste increase as plastic and paper contents increases. (Waste calorie also depends on water content.) At present, plastic and rubber share 6% and paper shares 7% on wet base based on the JICA Study on Waste Composition carried out in 1998. These percentages need to be roughly doubled to reach calorie of the self-burning level. In Japan, plastic/rubber share 12%, and paper shares 35% on wet base.

Remark:

Minimum calorie needed for self-burning (1,000 kcal/kg) is 40 % higher than 715 kcal/kg, the current calorie of Hanoi waste. Waste calorie increases as economic standard increases. However, there is no specific formula explaining the relationship between the two factors. The Japanese experience shows that the waste calorie increased from 1,250 kcal/kg in the year 1970 to 2,000 kcal/kg in 1999. This is a 60% increase over 29 years, and average rate of increase is 1.63%/year. Assuming the same rate is applied, it is estimated that it would take 20 years for Hanoi waste to reach 1,000 kcal/kg.

ii. For Power Generation:

Waste calorie must reach 1,500 kcal/kg at minimum for power generation.

b) Economic Conditions

As explained earlier, introduction of waste incineration will put a financial burden on the citizens if their income is less than $5,000/person/year.

Remark:

Assuming that current Hanoi GRP per capita is $760/person, and Hanoi will maintain 7% annual increase in GRP, and this can be decomposed into 2% population growth and 5% economic growth on per capita base, it would take about 40 years for Hanoi GRP per capita to reach $5,000/person.

c) Non-availability of landfill site within 300 km from waste collection

area as estimated earlier

It would not be necessary to introduce incineration as long as landfill sites are available within 300 km from the city center of Hanoi. If a landfill site cannot be sited within 300 km or so, and if an incinerator can be sited within HPC area, an incineration may become more economical than the landfill due to cost of waste transportation.

(b) Form of Ownership and Operation of Incineration Facility

There are two major forms. One is that HPC itself owns and operates incineration facilities. The other is BOO (Build, Own and Operate) arrangement, under which HPC makes a contract with a company that would build, own and operate waste incinerator. HPC would pay tipping fees to the company according to amount of waste incinerated based on an agreed price.

Two major advantages of BOO are as follows. First, HPC does not have to provide funds for investment, and therefore can be free from risks of investment. Second, operation of incineration would be more reliable as HPC can select a company having experience in waste incineration.

In case of BOO arrangement, there are suboptions. One sub-option is to permit a BOO company to make contracts with organizations (waste generators) other than HPC to receive waste. The other sub-option is to make a contract exclusively with HPC. The former provides more flexibility for a BOO company.

Experiences in Indonesia, Philippines, Thailand and some other countries show that private companies are cautious of participating in BOO arrangements if clients are not strong and reliable in the financial and administrative capacity.

(c) Location of Incinerator

The nearer an incinerator to waste collection area, the lower the cost of waste transport. However, the nearer an incinerator to waste collection area, the higher the cost of control of emissions such as dioxin required. Considering the land availability, planned Nam Son Waste Treatment Complex site may be a good candidate.

(d) Type of Waste

For better operation of incinerator, it is advisable that HPC will collect waste of higher calorie such as waste generated from offices that are rich in paper and other combustibles.

(2) Long Term Land Acquisition Policy and Plan

1) Necessity for Long Term Land Acquisition Plan and Policy

Nam Son landfill site is the firstlarge-scale landfill site for HPC. During the past decade, size of a landfill was 4 – 5 ha. It is now necessary for HPC to have a long term perspective and policy for acquisition of land for landfill.

2) Nam Son Landfill Site

According to HPC, it would acquire the site (about 80 ha) for Nam Son Solid Waste Management Complex at Soc Son by March 2000. The JICA Study Team estimates that Nam Son Phase 2 Landfill site will have a capacity of receiving 10 million tons of waste. It will last until the beginning of 2018 provided that it would start operation in the beginning of 2004.

3) Minh Tri (150 ha) or expansion of Nam Son landfill site

In future HPC should acquire further land for future landfill sites considering the following particular sites and general principles.

Minh Tri

During the course of the feasibility study for Nam Son Solid Waste Management Complex, HPC together with consultants have identified the four sites including Nam Son that has been selected. According to the feasibility study, Minh Tri has an area of 150 ha. There is a possibility that some more land may be available adjacent to the area identified.

The JICA Study Team considers that Minh Tri (one of the four candidate sites) may be a good site for landfill after the Nam Son landfill site is filled. As a matter of fact, Minh Tri was selected as the best site. However, HPC did not select this site because there was a plan to develop a golf course on this site. It seems that the golf course development plan was suspended so far. HPC is urged to reconsider the land use of Minh Tri.

4) Use of Mountain/Valley Areas

It is possible to use mountain and valley areas as landfill sites. Technology for construction and operation of landfill sites in such area is common. With this view in mind, more locations will appear as potential sites for landfill.

5) Inter-Provincial Landfill Arrangement (Acquisition of land outside HPC area)

In Japan and some other countries, there are many cases where two or more

cities have a common landfill site if the cities cannot find a landfill site within the area of jurisdiction. HPC should actively examine this possibility. If, for example, HPC can use a land in the southern province, the transport distance can be shorter than that to Nam Son landfill, and therefore the transport cost can be reduced.

HPC is considering the possibility of applying a waste incineration mainly because of difficulty in acquisition of land within HPC area. However, cost difference between the sanitary landfill and incineration option is very large. It is estimated that the landfill option is still more economical than the incineration option if landfill sites can be located within 300 km from the city center of Hanoi.

According to the new regulation concerning landfill issued on 14 October 1999, it is legally possible for local governments to use land outside jurisdiction of each municipality for landfill provided that the Prime Minister's approval is obtained.

It is likely that HPC can acquire land within 300 km from the city center.

(3) Waste Disposal Policy for Sub-urban Districts

1) Responsibility of Waste Management

HPC has already set a policy that each suburban district should be responsible for management of solid waste generated within each district. The JICA Study team considers that his policy is rational and realistic.

Each of the five suburban districts has already established an urban environment company in recent years.

2) Target Waste Disposal Amount

It is estimated that a total of 470 ton/day of solid waste is generated in the five suburban districts, of which 133 ton/day (28%) is collected. The following table summarizes estimated waste generation amount and target collection amount and ratios for some selected years.

Estimated Waste Generation, Target Collection Amount and Ratios of the Five Suburban Districts

	Estimated Waste Generation (ton/day)	Target Collection Amount (ton/day)	Target Collection Ratio
1999	470	133	28%
2005	570	204	36%
2010	671	294	44%
2015	780	414	53%
2020	908	586	65%

Collection amounts and ratios differ by districts. Gia Lam district collects 48 ton/day of waste, which is 38% of estimated generation amount.

Table 6.5.3 shows estimated waste generation amount and target collection amount for each suburban district though the period from 1998 till 2020.

3) Waste Disposal Method and Plan

In principle, each suburban district should apply the sanitary landfill.

It is estimated that each district would need 10 – 15 ha of land for sanitary landfill during the period of 2000– 2010, assuming that height of landfill is 10 m.

Each sub-urban district has identified future landfill sites within each district as shown below.

Outline of Future Landfill Sites Planned by Each Sub-Urban District

Name of sub-urban district	Location	Area
Gia Lam	Kieu Ky	5.4 ha for the first phase, 7 ha for the second phase
Dong Anh	Communes of Lien Ha and Viet Hung	10 ha
Soc Son	Nam Son Landfill Site (same as the one used by 7 Urban Districts)	
Thanh Tri	Brick soil excavated hol in commune of Vinh Quiynh	5.4 ha
Tu Liem	A paddy field located in communes of thu Phuong, Thuong Can, and Minh Khai	

Note: Some area of the first phase landfill site of Gia Lam was already used and filled with solid waste transported by URENCO.

Locations of each site are indicated in Fig.6.5.7.