Table 3-14: Results of Estimating the Financial Feasibility indicators

	Tipping Fee (bahts/ton)	NPV (bahts)	FIRR (%)
Case 1	200	-34,857,774	3.97%
Case 2	250	26,501,607	14.28%
Case 3	300	87,860,987	23.45%
Case 4	350	149,220,368	31.91%

As shown in the table above, the project will not be financially feasible as a private sector business if the tipping fee is not more than 200 bahts per ton of waste (FIRR is only about 4%). On the other hand, if the tipping fee is established more than 250 bahts per ton of waste, the project will be financially feasible in consideration of the current interest rate of short-term commercial lending, which is ranging from 7 to 12%. Although the assumption above does not include the cost of land and facility plan/design in the construction cost, it will still be financially feasible enough if the tipping fee is established at more than 350 bahts per ton of waste.

3.2.5 Proposal Concerning Standards and Regulations

a. Classification of Industrial Waste

Factories generate the following types of waste.

1. Non-hazardous waste
2. Hazardous waste
3. Waste similar to municipal waste not from production lines but from office works, canteens, etc.
4. Medical waste from health care facilities of factories (except for Item 3)
5. Radioactive waste

List of characteristics of waste and unusable materials attached to the Notification of Ministry of Industry No. 1 (B.E. 2541 or A.D. 1998) classifies non-hazardous waste into 2 groups, and each group is classified into sub-groups.

- Group 1: Non-hazardous waste characterized by type
- Group 2: Waste from specific production processes

Group 2 includes the following types of waste.

1. Ash generated from combustion process of fossil fuels, biomass and combustible material
2. Automotive parts and auto shredder wastes
3. Dust from air pollution control system including baghouse, electrostatic precipitator, cyclone and scrubber
4. Used catalyst from petrochemical production processes
5. Dust from cement kilns
6. Dewatered sludge from industrial wastewater treatment plant
7. Dewatered sludge from wastewater treatment plant in tannery
8. Drilling mud from petroleum exploration

9. Used refractory materials from industrial furnaces, kilns and ovens
10. Sand from sand blasting
11. Slag from coal gasification process
12. Sulfur dioxide scrubber waste from air pollution control system in fossil fuel combustion processes
13. Residuals or dust from tannery
14. Tailings from extraction, benefaction and processing of ores and minerals

The team proposes that DIW should exclude Group 2 (waste from specific industrial processes) from the category of Non-HW for the following reasons.

1. Since any type of waste in Group 2 is possible to be HW, treating these wastes as non-HW could result in serious consequences. It is safer that these wastes in Group 2 are classified as HW and treated/disposed of as non-HW only if they can be proved non-HW by tests such as leachate test;

2. There is some possibility that the leachate extraction procedures prescribed in the Notification of the Ministry of Industry shows the different result at each test.

3. There is some doubt whether waste generators (factories) submit a certificate or result of analysis to show that generated wastes are non-HW every time they discharge wastes.

4. There is some doubt whether waste treatment/disposal facilities carefully check the certificate or result of analysis or conduct a test to check if wastes they receive are non-HW or not when they receive wastes.

5. Since municipal waste disposal sites are not prepared to receive HW, a priority should be given to avoid possible influx of HW.

b. Licensing System to control the Private IWM Business

b.1 Control by the License

In order to control the entire flow of waste from the discharge point to the final disposal point, not only factories but also waste collectors/transporters and waste buyers have to be under control.

DIW has been controlling the discharge of Non-HW from factories located in 14 provinces including the study area of the present study by obligating them to apply for the transport permits as stipulated in MOI Notification No.1 B.E.2541 (1998). In order to strengthen this, the team proposes the development of a licensing system to control waste collectors/transporters and waste buyers (see Section 9.2.5).

That DIW has control over factories, waste collectors/transporters and waste buyers all together means that DIW has authority to impose a liability for illegal dumps or improper treatment. This should be effective to prevent illegal dumps and promote proper treatment.

Types of license for the transporters and the waste buyers should be established separately. The license will help the control over them at the following aspects.

- The collectors/transporters and waste buyers must have licenses if they wish to buy or transport waste of their client factories. Then they will be controlled under the licensing system.

- The transport permit is no more necessary if the licensing system works properly. Instead, Selling Record or Discharge Record of the waste must be prepared and kept for at least 5 years for factory inspection. In case of hazardous waste, it must be attached to Ro Ngo 6.

b.2 Requirements

b.2.1 Requirements to Waste Buyers

Waste Buyers are those who pay money to factories in exchange of their waste or unusable material. Requirements to them will be as follows:

- Waste buyers must have the license issued by DIW to buy waste or unusable material from factories for a recycle or selling purpose.
- Secondary or tertiary waste buyers, who buy waste or unusable material from other buyers, also must have the license.
- Waste buyers must give the factory a receipt when they buy the waste. The receipt specifies the type and quantity of waste. Waste buyers themselves must keep a copy of the receipt.
- Waste buyers shall make a Waste Purchasing and Selling Record describing the type and quantity of waste (bought or sold), client's name and other necessary data. The Record shall be kept for at least 5 years for factory inspection by the DIW.
- Waste buyers shall report the type and quantity of waste which they dealt with to DIW once a year.

b.2.2 Requirements to Waste Collectors/Transporter

It is supposed that there are 4 types of the waste collectors/transporters as follows:

- If the waste discharger himself transports waste to others by his own car, he must have the license.
- If he is a waste buyer who transports waste by his own transport means, he must have the license.
- If the waste treater or the user of recycled material himself transports waste by his own car, he must have the license.
- If the transporter just only transports waste under other's instruction, and he himself does neither buy nor sell waste to the other parties, he must have the license.

b.3 Changes in the Control over Factories

b.3.1 Requirements to Waste Dischargers (factory)

- No transport permit is required.
- When the factory sells waste to waste buyers, they must be licensed waste buyers.

- When the factory asks transporters to take their waste out of the factory, they must be licensed transporters.
- The factory must prepare the Selling Record or Discharge Record of the waste and keep it for at least 5 years for factory inspection. In case of hazardous waste, it should be attached to Ro Ngo 6 to be submitted to DIW.
- Discharge Record shall also be made when the factory asks a local administrative organization such as municipality to collect the waste.

It is recommended to amend the MOI Notification No.1 B.E.2541 (1998) that at present requires factories to get transport permits so as to regulate the requirements listed above, and to apply it to the whole country.

b.3.2 Requirements to Users of Recycled Material

Users of recycled material include factories of Code 105 that sort waste and factories of Code 106 that recycle waste. In either case, they are to be controlled as follows.

- Factories that use recycled material to sort and/or recycle shall prepare the Waste Purchasing Record. They must submit Ro Ngo 5 to DIW once a year with attaching the Waste Purchasing Record.

b.4 Action Required to the DIW

- Licensing system development
- Training for the transporters as a condition to give a license
- Close check of Ro Ngo 5 with respect to the material used
- Close check of Ro Ngo 6 with respect to the method of waste disposal
- Promotion of the registration of the factories as those of Code 105 and 106

At present, the Ro Ngo 5 report is submitted not to DIW but to the Office of Industrial Economies, but they should share the data.

c. Standards for non-HW treatment/disposal facilities

Basically, collection, transportation, reuse, recycling, intermediate treatment and final disposal of non-HW can be thought in the same way as those of municipal wastes. Therefore, standards for municipal waste treatment/disposal facilities can be applied to non-HW treatment/disposal facilities.

Minimum standards for facilities concerning collection, transportation, reuse, recycling, intermediate treatment, and final disposal of non-HW are summarized in the table below. They are referred to relevant standards in Japan.

The main responsibility of the government is to direct, monitor, and control the whole process of non-HW treatment/disposal. To direct all the business concerned to conduct proper IWM, and to monitor and control the whole process, it is necessary for the government to make standards clear. DIW need to draw up standards for each process of non-HW treatment/disposal and to prepare monitoring and control systems. Since it is in general very difficult to control on-site final disposal, DIW has to tighten regulation on on-site final disposal and to eliminate improper disposal.

Table 3-15: Operational Standard of IW disposal facilities

Standards for collection and transportation	1.Necessary measures to prevent litter and spillage of wastes from a vehicle and a container in the process of collection and transportation have to be taken.
	2.Necessary measures to prevent nuisances caused by odour of waste or noise/vibration by collection and transportation vehicles have to be taken.
	3.If wastes need to be transhipped, the following measures should be taken: • to fence around the transhipment place and put a bulletin board to show the purpose of the land use clearly; • to prevent litter/spillage of waste and penetration of leachate to underground; • to prevent odour; and • to prevent propagation of mice, mosquitoes and flies at the transhipment place.
	4.Storage of waste at the transhipment place is prohibited in principle.
Standards for reuse, recycle and intermediate treatment	1. Necessary measures to prevent litter and spillage of waste at the process of reuse/recycling or intermediate treatment have to be taken.
	2. Necessary measures to prevent nuisance caused by odour and noise/vibration from reuse/recycling and treatment process have to be taken.
	3. If wastes need to be incinerated, incineration facilities with proper structure and equipments have to be used.
	4. If waste is stored, storage place have to be fenced and a bulletin board have to be put to show the purpose of the land use clearly.
	5. If wastes need to be stored, the following measures should be taken: • to fence around the storage place and put a bulletin board to show the purpose of the land use clearly; • to prevent litter/spillage of waste and penetration of leachate to underground; • to prevent odour; and • to prevent propagation of mice, mosquitoes, and flies at the storage place:
Standards for land-filling	1. Necessary measures to prevent litter and spillage of waste by landfilling work have to be taken.
	2. Necessary measures to prevent nuisance caused by odour and noise/vibration brought with landfilling work have to be taken.
	3. For landfill operation, the following measures should be taken: • to fence around the landfill site and put a bulletin board to show the purpose of the land use clearly; • to prevent pollution of public water area and ground water by leachate from landfill site, if necessary; and • to prevent propagation of mice, mosquitoes, and flies at the landfill site.

d. Site Selection Procedures and Standards

d.1 Objectives and Limitation of the Proposed Criteria

d.1.1 Objectives

Evaluation criteria for site selection for facilities to treat or dispose of non-HW from industries do not exist yet. Generally speaking, the MOSTE's existing criteria for MSWM facilities could substitute them, but the MOSTE's criteria do not indicate a site selection method or detailed evaluation items, which are very important for decision-making.

Therefore the team elaborated draft site selection criteria for the management of non-HW and proposes them here based on its experience in the several countries including Japan. In addition the World Health Organization regional publication[4] is referred as a background material.

d.1.2 Limitation

Although the evaluation criteria may differ from each waste management facilities such as a transfer station, an incinerator and a landfill, the criteria for a landfill cover most of aspects required for the other facilities. Therefore, in order to supplement the existing criteria the team drafts a site selection method and its evaluation criteria for non-HW landfill.

An actual site selection work should be conducted fully taking regional conditions into consideration. Therefore, the team recommends the relevant organizations, which concern the selection work, examine the draft criteria and modify/improve the criteria to adopt local conditions in Thailand.

d.2 Proposed Site Selection Process

The site selection for a new landfill will take place in three phases as follows:

1. Phase 1: Preliminary selection with excluding criteria

   In the first phase, the search area is defined and consequently a number of candidate areas is reduced by excluding (strict) criteria.

2. Phase 2: Secondary selection with reducing criteria

   In the second phase, the areas that are identified as suitable for a landfill site according to the criteria of phase 1, are further reduced by using less strict criteria (reducing criteria). The effect and reach of the most reducing criteria can be adjusted according to needs and local conditions. After application of reducing criteria approximately 5 suitable locations for a landfill site should be left. If the number of the site is still much, reducing criteria should apply more strictly and try to reduce the number of site further.

3. Phase 3: Final selection with arranging criteria

   In the third phase, approximately 5 possible locations for a landfill site will be given scores based on the arranging criteria. The arranging criteria are divided into 5 subjects. According to their scores on each criterion, a separate ranking score will be given to each location for each subject. The ranking scores are accumulated in an overall scoring table. A weighing factor can be applied to

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[4] "Site selection for new hazardous waste management facilities", WHO Regional Publications European Series No46.

each subject if required. The sum of the (weighed) ranking scores defines the most suitable location for the landfill site.

The process of these site selections for a new landfill is illustrated in Figure 3-5.

d.3 Proposed Evaluation Criteria

d.3.1 Excluding Criteria for Preliminary Selection

As the phase 1 of the site selection, following criteria will be used for excluding certain locations, which are not suitable for the landfill.

Table 3-16: Summary sheet for excluding criteria

Is the searching area of a landfill located:	Answer
1. in a housing area	Yes / No
2. within XXX m around a housing area	Yes / No
3. within the influence zone around a water well	Yes / No
4a. in a protected area with ecological, historical or scientific value 4b. Within XXX m of such protected area	Yes / No Yes / No
5. in a military area	Yes / No
6. in a water inundation area	Yes / No
7. within 5 km from an airport	Yes / No
8. within XXX m from a cemetery	Yes / No
9. with impossibility of land acquisition	Yes / No

Note: "XXX" should be determined by relevant authorities.

d.3.2 Reducing Criteria for Secondary Selection

The aim of the reducing criteria is to reduce the search area for a new landfill once more using reducing criteria. The result of using the reduction criteria should be that there are 5-6 potential locations are left for a comparison about the most suitable location.

Table 3-17: Summary sheet for reducing criteria

Is the searching area of a landfill located:	Answer
1. far from collection area	Yes / No
2. in a bad accessibility	Yes / No
3. with difficult infrastructural provisions	Yes / No
4. with geological limitations	Yes / No
5. with hydrological and soil limitations	Yes / No
6. with availability of bottom/cover material	Yes / No
7. within a tourist/recreational area	Yes / No
8. within an industrial area	Yes / No

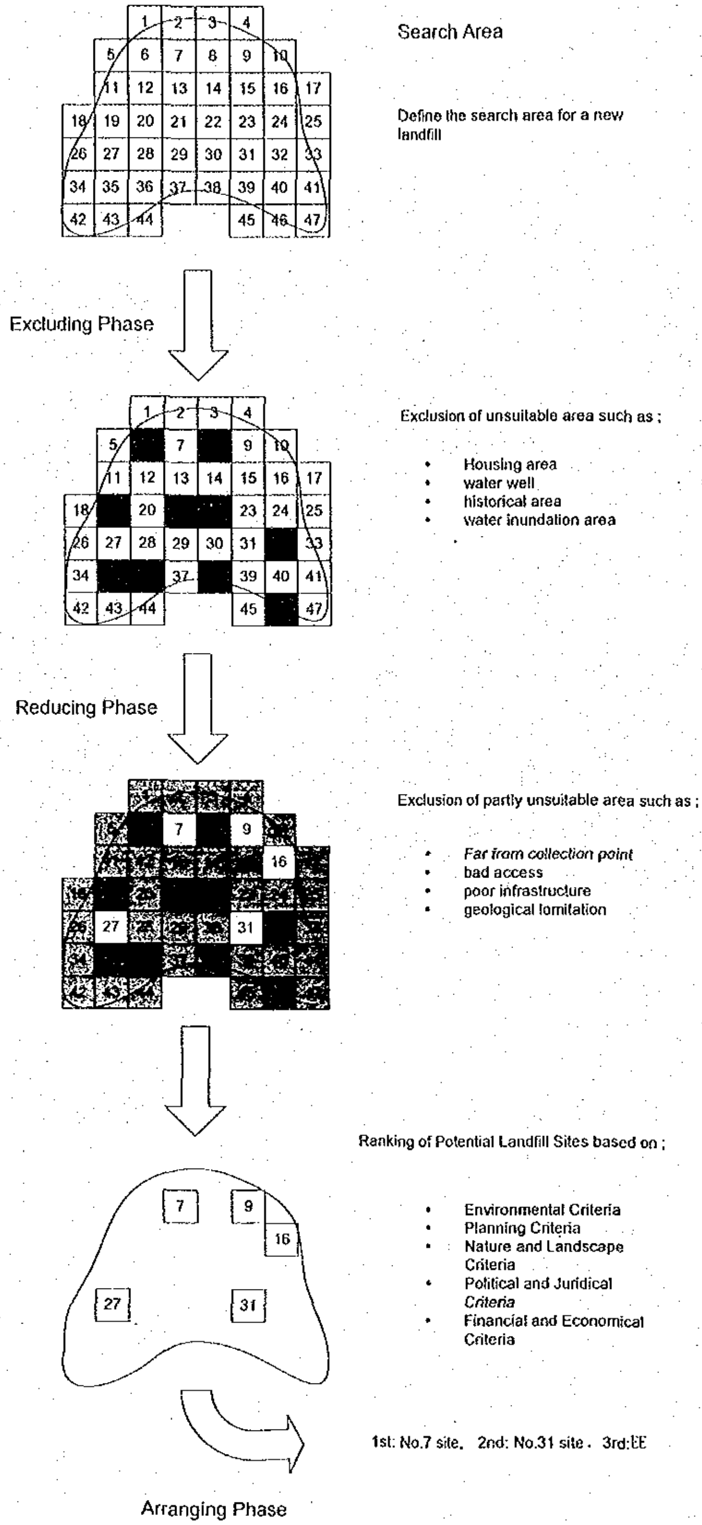

Figure 3-5: Site Selection Process for a new landfill

d.3.3 Arranging Criteria for Final Selection

The arranging criteria are meant for the comparison of several potential sites which are the outcome of phase 1 and 2 of the selection process. It is recommended not to compare more than 5 potential sites. If the outcome of the phase 1 and 2 has resulted in more than 5 sites, the criteria of phase 1 and 2 should be applied more strictly, in such a way that 5 potential sites are left.

The arranging criteria can be expressed by five tables below.

Table 3-18: Summary of the scores on environmental criteria

Environmental Criteria	**Locations**				
	A	**B**	**C**	**D**	**E**
1. permeability of the subsoil					
2. presence of impermeable layers in the subsoil					
3. susceptibility to soil consolidation					
4. position of vulnerable objects related to the direction of groundwater movement					
5. velocity of ground water flow					
6. groundwater and river levels					
7. odour and dust nuisance for neighbouring area					
8. nuisance by traffic generation					
9. risks for neighbouring area					
10. other nuisance for neighbouring area					
Total Score					
Average Ranking Score					

Table 3-19: Summary of the scores on planning criteria

Planning Criteria	**Locations**				
	A	**B**	**C**	**D**	**E**
1. shape of the area					
2. hampering infrastructural use					
3. distance to the housing area					
4. distance to the industrial, tourist and recreational area					
5. distance to the national conservation area					
6. distance to the main road					
7. distance to the waste generator					
8. possibilities for a usage after closure					
Total Score					
Average Ranking Score					

Table 3-20: Summary of the scores on nature and landscape criteria

Nature and Landscape Criteria	**Locations**				
	A	**B**	**C**	**D**	**E**
1. ecological value of flora					
2. ecological value of the fauna					

3. harmful effect on ecosystem					
4. cultural, historical value of the landscape					
5. possibilities for visual incorporation in the landscape					
Total Score					
Average Ranking Score					

Table 3-21: Summary of the scores on political and juridical criteria

Political and Juridical Criteria	**Locations**				
	A	**B**	**C**	**D**	**E**
1. acceptance by the regional government					
2. acceptance by the local authority					
3. hampering effect of other planning					
4. acceptance by the pressure groups involved					
5. ownership of the landfill area					
Total Score					
Average Ranking Score					

Table 3-22: Summary of the scores on Financial and Economic criteria

Financial and Economic Criteria	**Locations**				
	A	**B**	**C**	**D**	**E**
1. cost of land acquisition					
2. cost for the access of the landfill					
3. transport cost					
4. operation and maintenance costs					
5. extra cost for environmental protection					
6. cost for the after-care					
Total Score					
Average Ranking Score					

d.3.4 Summary of final score

For an overview and comparison all the average ranking scores of each criteria category for the different locations are brought together in table. Dependent how important a specific category, in comparison with other categories, is judged as essential in the decision making process, it is possible to give each category a different weighing factor. If environmental criteria is judged in such a way that they are twice as much more important than the planning criteria, the average ranking scores for the environmental criteria should be multiplied with two. Normally the weighing factors have a range of 0.5 to 2.5. The sample of this calculation sheet will be presented in Table 3-23.

Table 3-23: Final score for each location

Categories	Weighing Factor	Locations				
		A	B	C	D	E
Environmental Criteria						
Planning Criteria						
Criteria on Nature and Landscaping						
Political and Juridical Criteria						
Financial and Economic criteria						
Final Score						

The final score of each location is the sum of the weighing scores on the 5 categories of criteria. The location with the highest final score is most suitable as location choice for the new landfill.

3.3 HW Action Plan

3.3.1 Selection of Action Plan

a. Scope of Work of The Study Concerning A/P

The Master Plan on HW (M/P) is under discussion at DIW and even the draft of M/P has not prepared yet. The Scope of Work (S/W) of the present JICA study, signed by the both governments in November 2000, stipulates that one of the study objectives is "to formulate an action plan on hazardous waste management in the field of HW reuse/recycling, industrial cluster and zero emission concepts".

b. Selection of Action Plan

An action plan is to show a specific process of necessary actions to achieve the goal of the M/P. However, the HW M/P is still being developed by DIW and even the draft is not yet available.

According to the HW flow in 2001 obtained from the result of the factory survey, the reuse/recycling rate of HW is 18.2%, only one fourth of that of non-HW (more than 78%). On the other hand, more than half (54.3%) of HW is treated (32.8%) or disposed (21.5%) on-site, while only 15% of non-HW is treated or disposed on-site.

Taking all theses consideration into account, the study team decided to propose the following three A/Ps, while emphasizing the reuse/recycling of HW.

- Reuse/Recycling Promotion Plan
- Waste Exchange Plan
- Waste Minimization Plan

c. Target Year, Targets and Strategies of A/P

Since the HW M/P has not formulated yet, the team set the target year, target and strategies based on the result of the survey. The target year is set as 2005, same as non-HW M/P, considering the short-term implementation.

3.3.2 Waste Minimization Plan

a. Proper Management of HW and Action Plan of Waste Minimization at Sources

The action plan to promote proper management of HW and waste minimization at sources is shown below.

1. *Thorough Implementation of the Manifest System*

- According to exiting manifest sheet, the factories themselves should manage the HW discharge properly and report to DIW.
- As soon as the HW manifest system enforced by PCD/MOSTE is legislated, the factories should fulfil their responsibility of HW as generators and cooperate PCD in running the system effectively.

2. *Implementation of Waste Audit*

- The factories themselves should start the investigation to grasp the characteristics of HW and pollutants.
- The generators should obtain knowledge about HW and consciousness about proper management through grasping the actual status.
- Segregation of recyclable waste and un-recyclable waste should be completed.

3. *HW Minimization and Reduction*

- The conversion of materials, fuel and non-hazardous substances should be promoted.
- The conversion of process should be facilitated.
- The introduction of energy-saving and resource-saving facility and process should be promoted.

4. *Recycling*

- The recycling of HW inside the factory should be promoted.
- The introduction of unused and/or waste heat utilization system should be considered.

5. *Facilitation of Zero-emission Industrial Estate*

- The zero-emission plan in a model industrial estate should be drawn up.
- The zero-emission pilot projects in the model industrial estate should be implemented.

6. *Formulation of IWM Improvement Plans for Individual Industrial Sectors*

- Specific improvement measures for IWM can be different from sector to sector (and from factory to factory). IWM improvement plans should be formulated for each industrial sector. (The team presents the sector investment plan taking an example of the paint industry in Section 4.2.)

b. Measures necessary for A/P

For the achievement of the A/P, the following measures are necessary.

- Preparation of guidelines and manuals for waste management and waste audit inside factory
- Provision of information in terms of waste management and waste audit inside factory
- Promotion of ISO 14001 (Environmental Management System)
- Preparation of guidelines for use of recycled material
- Reviewing and provision of technology in terms of waste Reduce/Re-use/Recycling
- Examination of introduction of flowing economic incentives regarding waste minimization and recycling
    - Effluent Tax
    - HW Tax
    - Virgin Material Tax
    - Landfill Tax
    - Tax reduction of use of recycled material
    - Incentives for the investment to install and/or improve facilities for waste minimization and recycling (Low rate loan, Special depreciation, Tax reduction)
- Support for the planning and construction of facilities regarding waste material recycle and thermal recycle in the industrialized area like an industrial estate.

3.3.3 Reuse/Recycling Promotion Plan

a. Target

The targets of main components of A/P in the target year of 2005 were determined based on the following objectives, paying an attention to reuse/recycling of HW. Numerical targets are summarized in Table 3-24.

1. To try to keep the increase rate in the amount of HW generation up to 4.2% from 2001 to 2005, by promoting waste minimization at factories
2. To decrease the on-site disposal rate from 21.6% in 2001 to 8.3% in 2005, by tightening regulation on on-site disposal, in order to prevent further environmental degradation by inappropriate on-site disposal.
3. To increase the HW reuse/recycling rate from 18.2% in 2001 to 28.2% in 2005, while encouraging factories change the disposal method, from on-site to off-site, in order to achieve the above target.

Table 3-24: Targets of HW A/P

Item	Present (2001)	Target year (2005)
Generation Amount (ton/year)	557,456	580,909
Reuse/recycling rate (%*1)	18.2	28.2
On-site (%*1)	4.0	4.0
Off-site (%*1)	14.2	24.2
On-site final disposal rate (%*1)	21.6	8.3
Off-site treatment and final disposal rate (%*1)	37.3	41.2
On-site Reduction	22.2	22.3
On-site storage	0.7	0

*Remark *1: The figure is the ratio to the total generation amount.*

HW flow in 2005, which is realized if targets of A/P are achieved, is shown in the following figure.

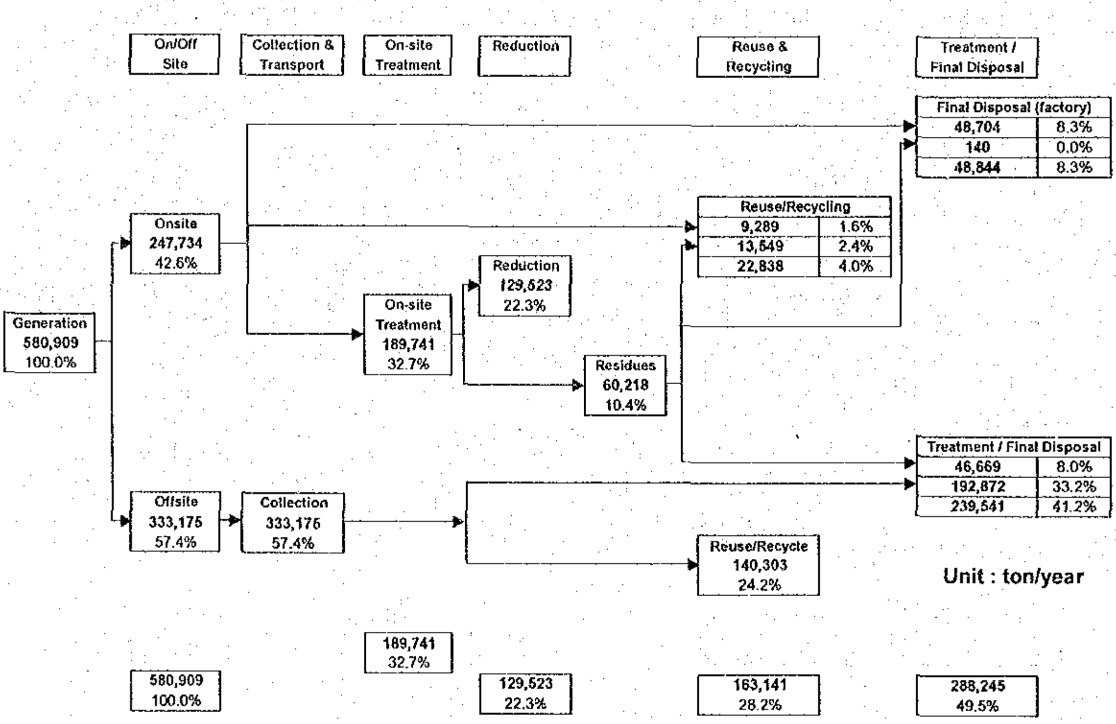

Figure 3-6: HW flow in 2005

b. Strategies

To achieve the abovementioned targets, the team strongly recommends the following steps.

1. **Promotion of HW recycling at cement factories**

   It is urgent issue to construct HW treatment/disposal facilities in Thailand, but it is extremely difficult to construct new facilities in the short-term due to strong opposition from local people. One of alternative plans is to utilize existing cement plants to treat HW. It can be said that utilization of existing cement factories is an effective way to promote HW reuse/recycling while making up shortage of HW treatment/final disposal facilities, because there is no need to construct new facilities and there are few residue from cement production process.

In the case of Japan in 1999, to produce 82,000,000 ton of cement, cement factories received 25,580,000 ton of waste as input materials, equivalent to 31% of production amount[5]. Considering the current production amount in Thailand, 46,000,000 ton/year[6], Thai cement factories could receive up to 14,260,000 ton/year of waste.

Therefore, the team proposes to utilize existing cement plants as a short-term improvement plan to make up the shortage of HW treatment/final disposal facilities and to promote reuse/recycling of HW.

2. **Nurturing waste analysis, adjustment and blending industries (waste blender)**

To promote utilization of waste at the cement factories, it is necessary to establish the system to guarantee the quality and quantity of wastes as input materials. In Japan, there are a lot of mediators (waste blenders), who analyze, adjust and blend wastes to guarantee the quality and quantity of wastes as input materials or fuels for cement production.

It is urgent in Thailand to nurture waste blending industry that can work as a mediator, as well as providing such service as analysis, adjustment, and blending of wastes, in order to promote waste utilization at cement plants.

3. **Promotion of HW reuse/recycling at other facilities**

There are other facilities, which can accept HW as input materials or fuels, and it is necessary to promote HW reuse/recycling there. In this case, priority should be given over improvement of existing facilities. In the first place, therefore, it is necessary to conduct a preliminary survey in order to make sure of the existence of facilities, which have a potential to receive HW, and then it needs to conduct a feasibility study to know quantity and quality of wastes which these facilities can accept, pollution control abilities, and feasibility of business.

4. **Improvement of the reuse/recycling system affecting the environment**

One of the major objectives of waste reuse/recycling is to avoid environmental burden given by the discharge of unnecessary material from production activities. Waste reuse/recycling can, however, affect the environment unless it is properly carried out. In the study area, there are found cases where economic benefit, another objective of waste reuse/recycling, comes first and waste reuse/recycling gives severe impacts on the environment. The environmental impacts are serious particularly when waste reused/recycled is hazardous and such reuse/recycling system should be urgently improved.

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[5] Tadahiro Mihashi, "Challenge to Zero- Waste Factory", Japan Institute of Plant Maintenance, September 2000.

[6] It is from the result of factory survey in July 2001.

In the present study, the team carried out a case study of waste oil and waste batteries recycling, and proposed improvement measures (see Section 4.1).

c. Improvement Plan of Cement Factories

The improvement plan should be divided into two part; improving cement plants (hardware) and enhancing management ability to receive and utilize wastes (software).

The main components of improvement plan concerning hardware can be summarized as follows.

- Installation of equipment to control grain size of solid waste by, for example, crushing
- Installation of waste feeder equipments
- Installation of burner for waste oil
- Installation of by-pass equipment for chlorine gas

The main components of improvement plan concerning software can be summarized as follows.

- Enhancement of ability to stabilize waste such as waste oil and sludge in terms of both quality and quantity by adjustment or blending

In this plan, those who are in charge of the latter (software) are waste blenders while cement factories are in charge of plant modification (the former, hardware).

The items and their outlines of the improvement plan at the cement production process are summarized in Table 3-25. Equipments for waste blending do not always have to be constructed in the cement factory. In Japan, waste blenders usually have facilities in their own factories. Figure 3-7 shows the improvement plan at the cement production process graphically. The numbers in the column of improvement items correspond to numbers in the figure.

Table 3-25: Improvement items at the cement production process

Process	Improvement items	Outline of improvement	Responsible organization
1. Raw material blending process	1. Solid waste shredding and feeding process	To install equipments to crush solid wastes to pieces small enough to put in the feeder.	• Cement factories • Waste blender
2. Calcination Process	2.1 Waste conveying and feeding process	To install equipments to feed waste into kiln. Several types of feeders are needed due to the size, shape and feeding point of wastes.	• Cement factories
	2.2 Waste oil injecting process	To install waste oil storage tanks and burner for waste oil. For this purpose, part of kiln requires remodeling.	• Cement factories • Waste blender
	2.3 Chlorine bypass system	To get rid of compounds containing high chlorine (KCl, chlorinated heavy metals, etc.) from the	• Cement factories

		production process and to control the quality of cement product.	

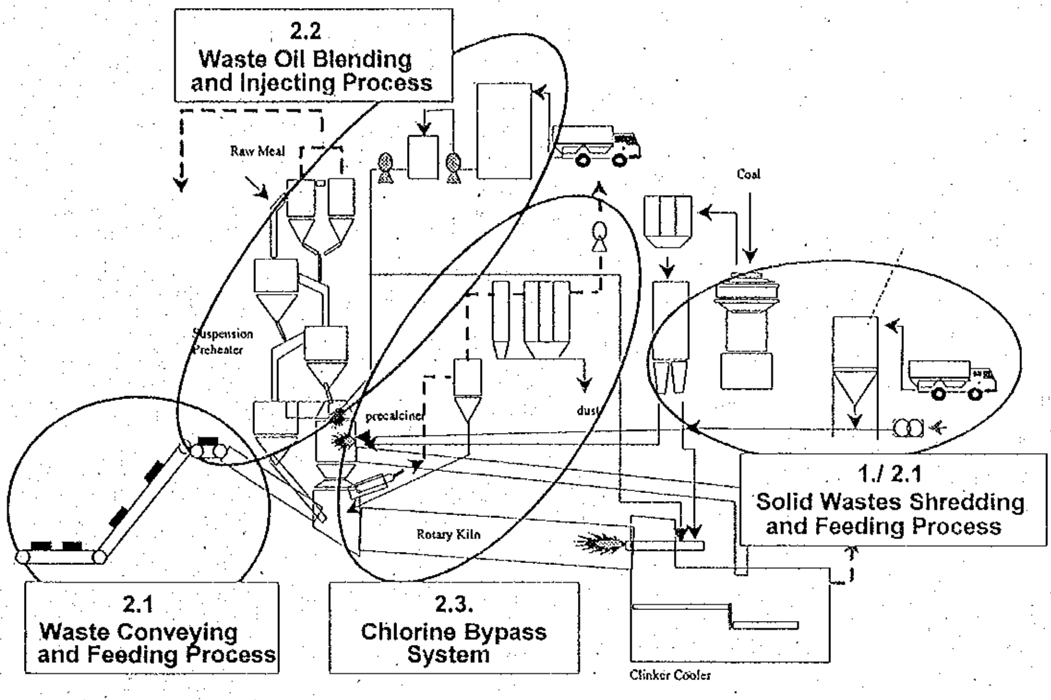

Figure 3-7: Concept of cement plant improvement

d. **Plan of nurturing waste analysis, adjustment and blending industries (waste blender)**

If there is enough information on wastes discharged from various factories, it is possible to guarantee the quality and quantity of wastes as raw materials and fuels for cement production by adjusting and blending these wastes. Those who do these businesses are waste blenders. In Thailand, only some companies such as GENCO has just started to work as waste blenders, and the waste blending industry should be further encouraged.

The point to be stressed is that turning waste into alternative raw material or fuel by waste blenders enables industrial sectors whose business is not recycling oriented to incorporate recycling activities into their production lines, and the cement industry is not the only example. The zinc smelting industry introduced in the next section is another. In this way, waste blenders are expected to take a leading role in the whole recycling system by collecting, transporting, mixing, adjusting and supplying waste, and to formulate an industrial cluster in which waste circulates effectively.

The current recycling system and future recycling system with waste blender taking a leading role are shown in Figure 3-8 and Figure 3-9, respectively. In the present industrial cluster, waste dischargers (factories) and conventional recycling factories are linked via waste buyers, and waste that is hard to recycle is discharged out of the cluster to be disposed of. As the waste blending industry develops, such hard-to-recycle waste starts to be supplied to existing industrial facilities such as cement kilns and zinc smelters, and the industrial cluster expands and gets closer to the zero-emission concept.

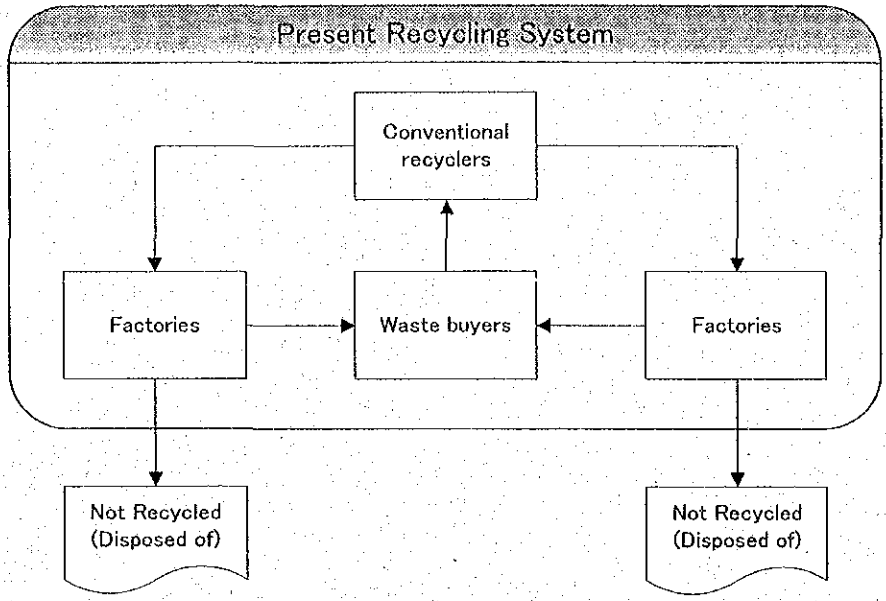

Figure 3-8: Current Recycling System

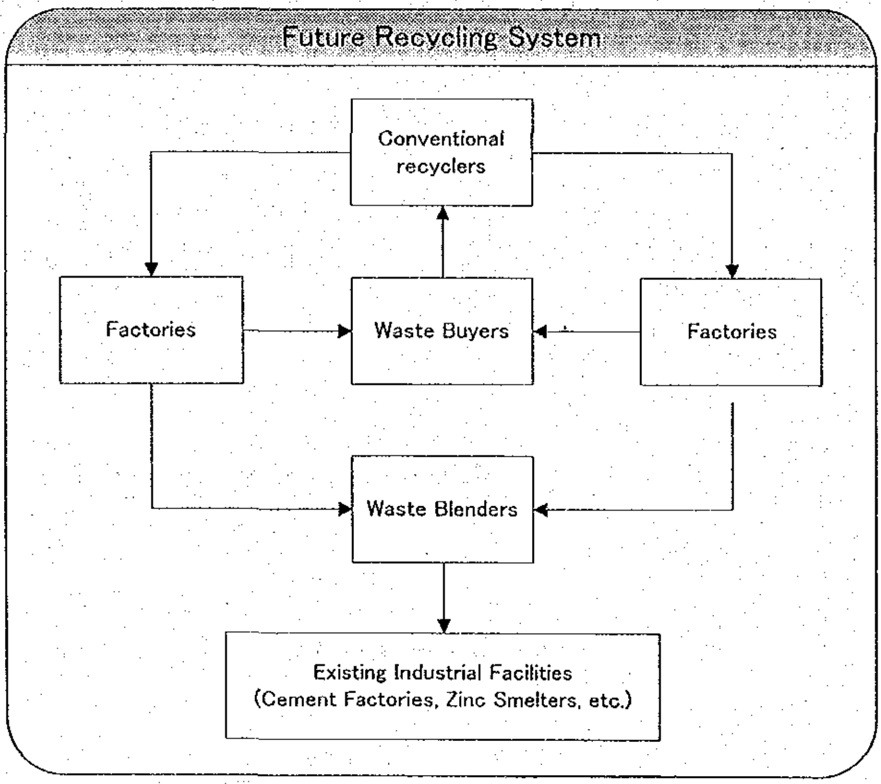

Figure 3-9: Future Recycling System

In order to propose approaches to nurture waste blenders in Thailand, the team studied how waste blenders are utilized in Japan with particular attention to regulations. The study is described in a separate report "the study on the use of waste blenders in Japan with particular attention to regulations" in Thai and English.

e. Plan of Zinc Recovery from Electric Arc Furnace Dust (An Example of HW Reuse/Recycling at Factories other than Cement Factories)

The HWs containing zinc, lead, copper and other heavy metals cannot be recycled in cement industry. In the case of Japan, such HWs are recycled by returning them to the non-ferrous metal industry, in which heavy metals in are reused as raw materials.

Although the HWs containing heavy metals are categorized as W03 (Heavy metal compounds) or W11 (Filter materials and treatment sludge) in the study, other HWs such as W04 (Liquid inorganic compounds) and W10 (Pickling waste) may also include heavy metals. According to the estimation in the study, the total amount of the above 4 categorized HWs that are not currently recycled reaches about 230 thousand tons per year.

Taking the above into account, the team here examines a plan of recycling heavy metals including zinc in electric arc furnace (EAF) dust, copper and lead in sludge and so forth by making use of the existing non-ferrous metal smelting facilities in Thailand.

Assuming that the amount of scrapped iron recycled is 2.5 million tons per year the amount of zinc recovered is estimated as shown in Table 3-26 below.

Table 3-26: Estimation of zinc recovery potential from EAF Dust in Thailand

Item	Amount	Remark
Amount of scrapped iron recycled	2,500,000 tons/year	Team's assumption
Generation of EAF dust in recycling of scrapped iron by electric arc furnace	50,000 tons/year	2% of scrapped iron
Amount of zinc in EAF dust	10,000 tons/year	20% of EAF dust
Amount of zinc recoverable	8,500 tons/year	Recovery ratio: 85%

On the basis of the current market price of zinc at approximately 46,700 bahts per ton, the income from selling the recovered zinc of the above amount is estimated to be 397 million baths per year.

Figure 3-10 shows the flow of heavy metal recovery in a zinc-smelting factory. Although the entire facilities given in this figure requires totally an initial investment of more than 300 million bahts, some of them such as dryer, wet scrubber, transportation equipment, and tanks may be available in the existing zinc-smelter in Thailand.

In introducing the process below, it is necessary to find solutions to tasks, such as availability of necessary facilities, the quantity and quality of acceptable EAF dust and heavy metal waste like sludge, and profitability.

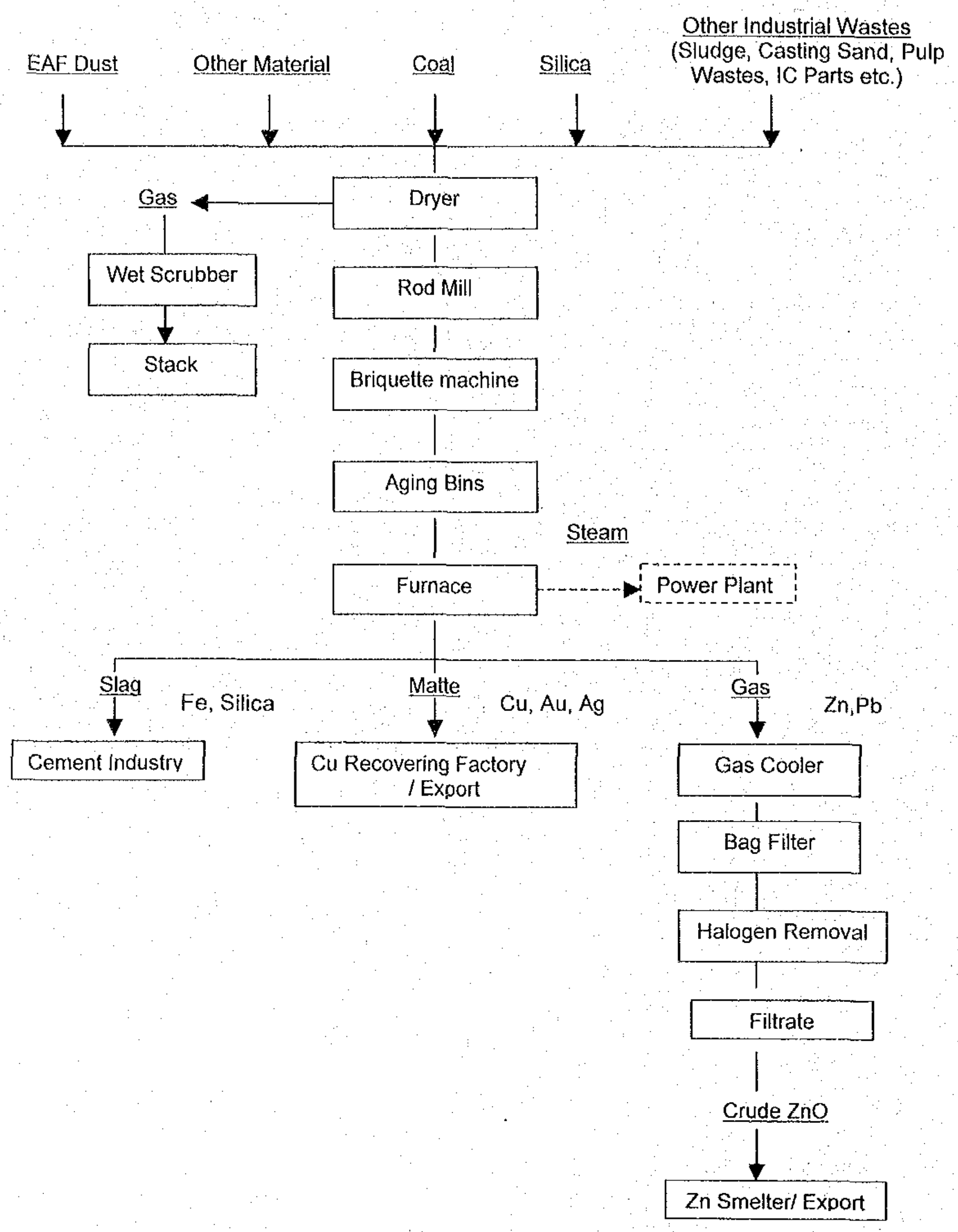

Figure 3-10: Flow of Heavy Metal Recovery from EAF Dust and other HWs

3.3.4 Waste Exchange Plan

DIW and the team established Waste Utilization Data Center (WUDC) in the pilot project of the present study. WUDC is, however, not fully utilized. The adequate use of WUDC needs to solve such questions as below.

- How to disseminate WUDC
- How to realize waste exchange

The action plan of measures to be taken in a short-term is proposed below.

a. Dissemination of WUDC

Using media close to factories will be the easiest way to disseminate WUDC.

One of such media is FTI, which has a wide network with various industries. WUDC will be disseminated to the member companies through the clubs of industrial sectors, and urge the companies to access to the WUDC website, or to send completed registration forms, supply sheets, and/or demand sheets to the FTI headquarters. The FTI headquarters then deliver those forms, or they may enter the information on the forms on the WUDC website on behalf of the factories that filled in the forms.

The other medium is DIW regional offices, which are 75 over the country and have 600 inspectors in total. Since they inspect factories located in the area, they should have close contact with them including even small or medium size factories which do not have FTI memberships. If the DIW regional offices can gather information on the demand for waste exchange in the area and data can be entered on the internet through them, WUDC will be extended to a national scale program. Meanwhile, DIW should develop its O&M system as the number of users increases.

b. Promotion of Waste Exchange

New industrial codes, 105 for waste sorting and landfilling and 106 for waste reuse/recycling, were created in December 2001. Since factories that would be registered at MOI as code 105 or 106 factories can be agents who mediate between waste suppliers and waste demanders, factories engaged in such business should be strongly encouraged to register themselves.

Once they are registered, then the advantages to use WUDC for their business should be understood and WUDC user registration will be promoted. It will be useful to hold workshops similar to what was held during this study, where participants will learn how to use the WUDC website and how to complete the user registration form and the demand sheet. It will be also desired to receive feedbacks from them so that they can find waste that they really want more easily.

3.3.5 Financial Appraisal of Projects

This section presents three types of action plans for HW management.

1. Waste minimization plan
2. Reuse/Recycling promotion plan
3. Waste exchange plan

The first item "waste minimization plan" should be implemented by individual factories under their conditions, and the contents and necessary cost vary. The last item "waste exchange plan" is the promotion of the existing program and does not require initial investment. Therefore, the team demonstrates here the financial appraisal of the following three projects in connection with the second item "reuse/recycling promotion plan"

1. HW Recycling by Improved Cement Factory
2. HW Blending Project for Recycling at Cement Factory
3. Zinc Recovery Project from EAF Dust together with Recycling of Waste Containing Heavy Metals

In the financial appraisal presented below, the team had to assume many conditions and the analysis is still rough. In order to implement the projects, it is necessary to conduct a feasibility study, which includes further examination of demand for HW recycling or treatment.

a. Financial Appraisal of HW Recycling by Improved Cement Factory

a.1 Amount of HW that can be recycled or reused in cement industry

Out of the target amount of HW recycling and reuse of about 140 thousand tons per year in the year 2005, which is established in the HW A/P, approximately 56 thousand tons are assumed to be recycled at cement factories, as shown in Table 3-27 below.

Table 3-27: Estimated Amount of HW to be recycled or reused in cement industry (2005)

Type of HW	Amount to be recycled or reused (2005) (ton/year)
Waste oil	22,083
Organic HW (sludge, etc.)	33,927
Total	**55,965**

a.2 Cement kiln improvement works and its estimated cost

The team here estimates the cost of facility improvement in cement factories to recycle HW by making use of the existing cement kilns. Table 3-28 below shows the improvement cost by items per one unit of cement kiln.

Table 3-28: Cost of Facility Improvement in Cement Factories for HW Recycling

Unit: per one unit of cement kiln

Improvement Items	Cost	
	US$	Bahts
Chlorine bypass installation works (2.3)	890,000	38,270,000
Waste conveying and feeding equipment (2.1)	370,000	15,910,000
Solid waste crushing and feeding equipment (1./2.1)	740,000	31,820,000
Waste oil injecting equipment (2.2)	190,000	8,170,000
Total	**2,190,000**	**94,170,000**

US$ 1 = 43 Bahts
Numbers in brackets correspond to Figure 3-7.

a.3 Financial Appraisal of HW Recycling by Improved Cement Factory

Based on the cost estimation above, the team here made a preliminary financial feasibility assessment of the HW recycling by the improvement of four cement kilns. The preconditions for this financial appraisal are given in Table 3-29 below.

Table 3-29: Preconditions of the Project

<table>
<tr><td>Project Period</td><td>11 years including 1 year for construction and 10 years for operation</td></tr>
<tr><td>Project Income</td><td>Reduction of lignite consumption cost by substituting waste oil for lignite at the amount of 22,038 tons per year equally by 4 kilns
<table>
<tr><th>Fuels</th><th>Unit price (bahts/kg)</th><th>Calorific value (kcal/kg)</th></tr>
<tr><td>Waste oil</td><td>0.5</td><td>7,000</td></tr>
<tr><td>Lignite</td><td>1</td><td>5,000</td></tr>
</table>
Cost reduction rate by substituting 1kg of waste oil for lignite: 0.9 bahts/kg of waste oil
Amount of waste oil substituted for lignite: 5,500 tons/year
Total cost reduction: 4,950,000 bahts/year
Treatment fee of organic HWs
Treatment fee: established between 1,000 and 2,500 bahts
Treatment amount: Equally dividing by 4 kilns 33,927 tons per year organic HWs based on the assumption of the recyclable amount in A/P, about 8,500 tons are accepted by one kiln every year during the operation period.</td></tr>
<tr><td>Project Expenses</td><td>Initial Investment for facility improvement: 94,170,000 bahts
Operation cost: 941,700 bahts
(assumed as 1 % of the initial investment)</td></tr>
<tr><td>Discount Rate</td><td>10% (assumed taking into account commercial interest rate, inflation, etc.)</td></tr>
</table>

Under the preconditions established in the table above, the team evaluates the financial viability of the project by estimating the NPV and FIRR. Table 3-30 below shows the results of estimation.

Table 3-30: Results of Financial Feasibility Indicators by Cases

	Treatment fee of organic HW (Bahts/ton)	NPV (Bahts)	FIRR (%)
Case 1	1,000	-15,738,101	5.5
Case 2	1,500	8,002,272	12.1
Case 3	2,000	31,742,645	18.1
Case 4	2,500	55,483,018	23.6

As shown in the table above, FIRR of the project exceeds 10% in Case 2 of setting the treatment fee at 1,500 bahts per ton of organic HW. Even taking into account other various possible risks arising in the project, it is estimated to be financially viable in terms of private sector investment if the treatment fee is established at more than 2,000 bahts per ton.

b. Financial Appraisal of HW Blending Project for Recycling at Cement Factory

b.1 Cost Estimation

The preconditions established for cost estimation are as follows:

- All the HWs that are planned to be accepted for recycling in the cement factories in 2005 are assumed to be pre-treated by HW blending industry. Therefore, the amount of HW treated in the blending industry will be as shown in Table 3-31 below.

Table 3-31: Estimated Amount of HW Treated by HW Blender

Type of HW	Amount Treated (tons/year)	Amount Treated (tons/day)
Waste Oils	22,038	74
Solid Waste (Organic HW)	33,927	113

Daily treatment amount is estimated based on the annual working days of 300 for both facilities.

- The project cost does not include the costs of land, power receiving and transform stations, offices, and heavy equipment.
- Assuming that 8 (eight) blending factories will be built in the Study area, the Study set up the treatment capacity of each blender as shown in Table 3-32 below.

Table 3-32: HW Treatment Capacity of the Blender

Unit: per blender

Type of blending facility	Treatment capacity (ton/day)
Waste oil mixing facility	10
Solid waste (organic HW) blending facility	15

Table 3-33 shows the result of preliminary estimated costs of waste oil mixing and solid waste (organic HW) blending facilities respectively. The cost of waste oil mixing facility is 35.69 million bahts per unit while installation of solid waste blending facility costs about 5.246 million bahts per unit.

Table 3-33: Cost of HW Blending Facilities (per unit)

Type of Facilities	Cost (thousand bahts/unit)
Waste oil mixing facility	35,690
Solid waste (organic HW) blending facility	5,246

b.2 Financial Appraisal of HW Blending Project

Based on the estimated cost of HW blending facilities above, the study here makes a preliminary financial appraisal of HW blending project by estimating NPV and FIRR of the project. Table 3-34 below shows the preconditions of the project established for its preliminary financial appraisal.

Table 3-34: Preconditions of the HW Blending Project

Project Period	11 years including one year's construction and 10 years' operation.
Project Income	Income from the selling of blended waste oil to cement factories for alternative fuel. 500 (bahts/kg) X 3,000 (tons/year) = **1,500,000 (bahts/year)** In receiving waste oil, the blender only charges the cost of collection and transport without any profit. Profit only comes from the selling of blended waste oil to cement factories. Income from charging the treatment fee of solid waste to generators. Treatment fee levied: to be established by cases between 4,000 and 5,500 bahts per ton Treatment amount: 4,500 tons/year The treatment fee includes (i) the cost of transportation from a blending factory to a cement factory and (ii) the fee to be paid to cement factories for final treatment of blended wastes. The waste dischargers shall bear the cost for collection/transportation from themselves to the blenders in addition to the treatment fee.
Project Expenses	Initial investment Waste oil mixing facility: 35,690,000 bahts Solid waste blending facility: 5,246,000 bahts Operation cost (estimated based on the examples of blending industry in Japan) Waste oil mixing facility: 3,569,000bahts/year (10% of initial investment) Solid waste blending facility: 210,000bahts/year (4% of initial investment) Payment of treatment fee to the cement factories (treatment of blended solid waste: 2,000 (bahts/ton) X 4,500 (tons/year) = 9,000,000 (bahts/year) Cost of transporting the blended waste to cement factories 250 (bahts/ton) X 4,500 (tons/year) = 1,125,000 (bahts/year)
Discount Rate	10% (assumed taking into account commercial interest rate, inflation, etc.)

The result of estimating the financial feasibility indicators (NPV and FIRR) is given in Table 3-35.

Table 3-35: Results of Financial Feasibility Indicators by Cases

	Treatment fee of solid waste (bahts/ton)	NPV (bahts)	FIRR (%)
Case 1	4,000	-5,954,563	6.1%
Case 2	4,500	6,613,870	14.0%
Case 3	5,000	19,182,302	21.0%
Case 4	5,500	31,750,735	27.5%

As shown in the table above, the project will obtain more than 10% of FIRR if it collects treatment fee of solid waste from the generators at the rate of 4,500 bahts/ton of waste (the dischargers shall also pay collection/transportation cost to deliver their waste to the blenders). Although the actual initial investment is expected to be larger if including the cost of land acquisition and other miscellaneous expenses, the project will be financially feasible enough as a private investment project if the treatment fee of solid waste is established at 5,000 bahts per ton of waste, which is still lower than the current rate of treatment fee in Thailand.

c. **Financial Appraisal of Zinc Recovery Project** from EAF Dust together with Recycling of Waste Containing Heavy Metals

c.1 Estimation of the Project Cost

Based on the similar cases in Japan, the costs of initial investment and annual operation of the facilities are estimated in Table 3-36 below.

Table 3-36: Estimated Cost of Zinc Recovery Project

Item	Cost (thousand baths)	Remark
(1) Initial Investment	**232,000**	
Zinc oxide (ZnO) recovery plant	232,000	
Lifting and storage facility	29,000	
Dryer	19,000	
Crushing and briquetting facility	49,000	
Furnace and ZnO recovery facility	47,000	
Incidental facilities	49,000	
Buildings, etc.	49,000	
Zinc recovery facility	0	Existing smelter will be used.
Item	**Cost (thousand baths/ton)**	**Remark**
(2) Facility Operation		
Zinc oxide (ZnO) recovery plant	4,850	Per ton of ZnO recovery
Raw materials	2,150	Coal, silica, binders are included
Utility	2,200	
Manpower and maintenance	500	
Zn recovery (refining)	15,000	Per ton of Zn recovery

c.2 Preliminary Financial Appraisal of the Project

Based on the project cost estimation above, the team made a preliminary financial appraisal of the project by estimating the NPV and FIRR under the preconditions given in Table 3-37 below.

Table 3-37: Preconditions of the Project

Project Period	11 years including 1 year's construction and 10 years' operation
Project Income	Income from selling zinc recovered from EAF dust

	Unit price of zinc : 46,700 bahts/ton Amount of zinc recovered : 8,500 tons/year Annual income : 396,950,000 bahts/year It is assumed that EAF dust is collected from the generators by charging the collection and haulage cost only. Income from treatment of sludge containing heavy metals Treatment fee : to be established by cases between 1000 and 2000 bahts per ton Treatment amount : 15,000 tons/year (to be assumed as 30 % of EAF dust accepted)
Project Expenses	Initial investment : 232,000 thousand bahts Operation cost : 370,000 thousand bahts/year ZnO recovery:4,850 (bahts/ton) X 50,000 (tons/year) = 242,500 (thousand bahts/year) Zn recovery: 15,000 (bahts/ton) X 8,500 (tons/year) = 127,500 (thousand bahts/year)
Discount Rate	10% (assumed taking into account commercial interest rate, inflation, etc.)

Estimation of NPV and FIRR was made on assumption of the treatment cost of sludge at 1000, 1500, and 2,000 bahts per ton respectively. Table 3-38 below shows the result of estimation.

Table 3-38: Results of Financial Feasibility Indicators by Cases

	Treatment fee of sludge (bahts/ton)	NPV (bahts)	FIRR (%)
Case 1	1,000	23,423,355	12.5%
Case 2	1,500	65,317,130	16.8%
Case 3	2,000	107,211,906	20.9%

FIRR of the project is more than 10% in the case of establishing the treatment fee of sludge at 1,000 bahts per ton as shown in the table above. Even though taking into account various possible risks that may arise in the project, the project is estimated to be financially viable if applying the treatment fee of sludge at 1,500 bahts per ton as far as the quantity of EAF dust and sludge is maintained at the level given in Table 3-37 even though electric arc furnace dust is collected only at the expense of collection and haulage.

3.3.6 Implementation Framework

Table 3-39 shows an implementation framework of the A/P proposed in this section.

Table 3-39: Implementation Framework of HW A/P

		Implementing Body	Year 2002	2003	2004	2005	Notes, Costs
A.	Waste Minimization A/P						
1	Thorough implementation of manifest system	DIW／Private sector		After the system legally set up			Close cooperation with PCD.
2	Waste audit	DIW	Guidelines, education, dissemination				
		Private sector		Implementation			
3	HW minimization and reduction	Private sector	Examination and implementation based on waste audit (item 2)				
4	HW Recycling at source	Private sector	Examination and implementation based on waste audit (item 2)				
5	Facilitation of zero-emission industrial estate	DIW・IEAT	Planning, deciding a model IE		Pilot implementation at the model IE		
6	Formulation of IWM Improvement Plans for Individual Industrial Sectors	DIW	Selection of priority sectors				Example of paint industry in Section 4.2.
				Implementation in order of priority			
B.	Waste Reuse/Recycling A/P						
1	Promotion of HW recycling at cement factories	Private sector	Facility improvement, diversifying types of waste received				Cost estimation in Section 3.3.5.
		DIW	Code 101 authorization to cement factories				
2	Murturing waste analysis, adjustment and blending industries	DIW	Promotion policy				
		Private sector		Development of blending business			Cost estimation in Section 3.3.5.
3	Promotion of HW reuse/recycling at other facilities	DIW	Investigation and promotion				
		Private sector			Implementation		Cost estimation in Section 3.3.5.
4	Improvement of the reuse/recycling system affecting the environment	DIW	Selection of priority wastes				Examples of waste oil and waste batteries in Section 4.1.
				Implementation in order of priority			
C.	Waste Exchange A/P						
1	Dissemination of WUDC	DIW	P/P continued and developed				See Section 4.3.
2	Promotion of the realization of waste exchange	DIW	P/P continued and developed				See Section 4.3.

4 Implementation of Action Plans and Pilot Projects

4.1 Improvement Plan for Waste Oil and Waste Battery Recycling

4.1.1 Background and Objectives

a. Background

In order to formulate non-HWM master plan (M/P) and HW action plan (A/P), the team covers all the industrial sectors, but is not going to study a particular industry in depth. Therefore, the plans to be made will be rather general and common to all the sectors. However, the team has recognized that for the actual realization of the M/P or the A/Ps, the development of improvement plans for each industrial sector is necessary, and sector-specific planning requires sector-specific expertise and experience.

Meanwhile, the team recognized that the sectors of waste oil recycling and waste battery recycling require the most immediate improvement measures.

The team therefore proposed the additional component of the said study to deal with this matter to JICA and the proposal was accepted.

b. Objectives

The additional component aimed to demonstrate the formulation of specific improvement plans for waste oil industry and waste battery industry, and to examine how DIW should guide the factories toward improved waste management in terms of hazardous waste reuse and recycling.

4.1.2 Improvement Plan for Waste Oil Recycling

a. Current Issues

Factories that the team could visit during the study employ a sulfuric acid/activated clay process to recover lubricating oil from waste oil. As lubricating oil is produced by the sulfuric acid/activated clay process, sulfuric acid pitch, which is strong acid and very reactive, and waste clay containing oil are also produced as waste. Currently part of sulfuric acid pitch is landfilled on-site and the rest is treated and disposed of by HW treatment/disposal enterprises. On the other hand, most of waste clay is landfilled on-site.

On-site disposal of these kinds of waste can cause a large environment problem since it is associated with high possibility of groundwater and soil contamination. Sulfuric acid pitch is particularly hazardous since it generates sulfurous acid gas. The handling of this waste is difficult and the treatment and disposal fee can substantially rise in future, although the fee is at present reasonable. Therefore, waste treatment will turn into a great concern.

b. Improvement Plan

As a short-term improvement plan, proper treatment of waste generated in waste oil recycling should be promoted. In other words, sulfuric acid pitch that is disposed of on-site must be properly treated and disposed of by HW treatment/disposal enterprises. Waste clay should be diverted from on-site landfill to cement factories to be recycled.

In the mid- and long-term, it is anticipated that waste treatment fee rises and exceeds benefits from production. It will be, however, difficult to encourage factories to change the process lubricating oil recovery from the sulfuric acid/activated clay process to another because it has a large advantage over other processes in terms of product quality. Therefore it will be necessary to change the production process and/or to start a new process to produce the following.

- Fuel oil
- Mixed fuel

4.1.3 Improvement Plan for Waste Battery Recycling

a. Current Issues

DIW and PCD has established a committee on the improvement of waste battery recycling industry in order to promote environmental countermeasures in waste battery recycling industry. If a factory is designated by the committee to be well managed environmentally, its product enjoys 5% tax exemption. Four factories among those the team visited during the study are such designated factories. The rest four factories are not operating or carrying out factory modification according to an order of improvement. Overall, unlike the situation of waste oil recycling industry, the factory operation of waste battery recycling has not seriously affected the environment.

Waste battery recycling as a whole, however, has the following problems, whose environmental influence may be worse than that of waste oil recycling.

- Illegal dumping of sulfuric acid

Sulfuric acid in almost all of waste batteries is illegally dumped before recycling factories receive them. It is anticipated that an environmental impact given by the illegal dumping of sulfuric acid is widespread and serious.

- Illegal primary smelters

There are many illegal primary smelters which are not registered with DIW. According to the interview at the factories, these illegal primary smelters deal with about 40% of primary smelting of the whole country. The illegal primary smelters not only pollute the environment, but also affect the operation of the designated factories which bear substantial cost for environmental conservation. In fact, the price of a waste battery has risen in spite of the decrease in the price of recovered lead.

b. Improvement Plan

The team proposes an improvement plan as below in order to prevent sulfuric acid from illegally dumped and to eliminate the illegal primary smelters.

Item	Short-term	Mid- and Long-term
Prevention of illegal dump of sulfuric acid	• To understand the recycling route of waste batteries. • To introduce a registration system of waste battery	• To strengthen the control (inspection, exposure and penalty) over waste battery recycling factories which

	collectors/dealers. • To strengthen the control (exposure and penalty) over sulfuric acid illegal dumping. • To ask for public cooperation for the prevention of sulfuric acid illegal dumping.	purchase waste batteries not containing sulfuric acid inside. • To introduce a manifest system to waste battery recycling.
Elimination of illegal primary smelters	• To strengthen the control (exposure and penalty) over illegal primary smelters. • To strengthen the control (exposure and penalty) over secondary smelters which purchase primary crude lead from illegal primary smelters. • To direct battery manufacturers to purchase recovered lead from the recycling factories designated by the committee on the improvement of waste battery recycling industry.	• To ask for public cooperation for the elimination of illegal primary smelters and to establish a public control mechanism. • To introduce a manifest system to waste battery recycling.

If the illegal dump of sulfuric acid and the illegal primary smelters are adequately controlled as a result of the implementation of the above plan, waste battery recycling factories need to be equipped with sulfuric acid treatment facilities which mainly consist of the following.

- scrubber facility to remove SO_2 from waste gas
- wastewater treatment facility to remove sulfuric acid and heavy metals from wastewater.

4.2 Formulation of IWM Plan for the Paint Industry

4.2.1 Background and Objectives

a. Background

It is recognized that the paint industry in Thailand has pressing concerns about its waste management derived from such issues as the shortage of appropriate waste treatment and disposal facilities. Especially, waste minimization and proper treatment require urgent improvement. Although the main task of the current study is, as the S/W specifies, the formulation of industrial waste management master plan and did not intend to look at a particular industrial sector in depth, DIW requested JICA in March 2002 to additionally carry out the study for waste management improvement in the paint industry and formulate an improvement plan, and the request was approved.

b. Objectives

The objectives of this component are as follows.

- Formulation of waste management improvement plan for the paint industry.

- Upgrading of DIW's knowledge on the sector-specific waste management improvement plan through the attainment of the above objective.

4.2.2 Improvement Plan

a. Current Issues of IWM

Using the result of the interview survey at the 11 paint factories, the team estimated the total waste generation from paint factories located in the study area at about 16,000 tons/year. The factories discharge 64% of this amount out for off-site treatment and/or final disposal. They have to pay for off-site treatment and/or final disposal of 24% of total generation.

The team drew the following findings regarding IWM at the paint industry from the factory survey.

1. The rate of total waste (including valuable waste and invaluable waste) to total paint production amount is much lower in the study area than that in Japan. According to the study done by Japan Paint Manufacturers Association, this rate in Japan is 6.4% (the average of 112 member companies of the association in 1999, tonnage base), whereas it is 2.9% on the average of the 11 factories. The reason will be that materials regarded as waste in Japan go back to the production lines in Thailand and are not counted as waste. This results in waste reduction. Such practice in Thailand seems to be attributed to lower cost for labor force than for raw materials.
2. The waste reuse/recycling activities of the factories are significantly active. The rate or reused/recycled waste to total generation is 56% in the study area, while it is 44% in Japan.
3. Therefore, the current problem with IWM for the factories is waste which has to be treated and finally disposed of off-site with payment. whose treatment/final disposal. It includes, in the order of amount, sludge, waste paint, wastewater, dust, metals, paper, cotton and plastics. The last four items are in so small quantity that they are not a problem.
4. Among those types of waste to be paid for off-site disposal, waste paint, especially gelled paint, is of a particular problem. The factories are frustrated with high disposal cost and inadequate collection service. The major method applied for disposal is landfilling, and whether it is properly managed is questionable.
5. About 90% of waste solvent generated is taken out of the factories and fully recycled. Although being paid by the recyclers, the factories are interested in generation reduction and on-site reuse/recycling of waste solvent, since the proportion of the cost for solvent as raw material to total production cost is not small.

b. Goals

The team formulated an improvement plan for IWM of the paint factory aiming at (i) waste reduction as much as possible, (ii) reuse/recycling of waste that can not be reduced, and (iii) appropriate treatment and final disposal of waste finally discharged.

From the view point of these three points, the current status of IWM of the paint industry can be evaluated as follows.

1. The paint factories have been making significant efforts to reduce waste.
2. They have been reusing/recycling waste as far as they can.

c. **Future Waste Flow**

With such understanding about the present IWM of the paint industry, it is important to maintain the current high level of waste reduction and reuse/recycling. Therefore, the team set the future waste flow as shown below considering that the present flow should be kept in 2010.

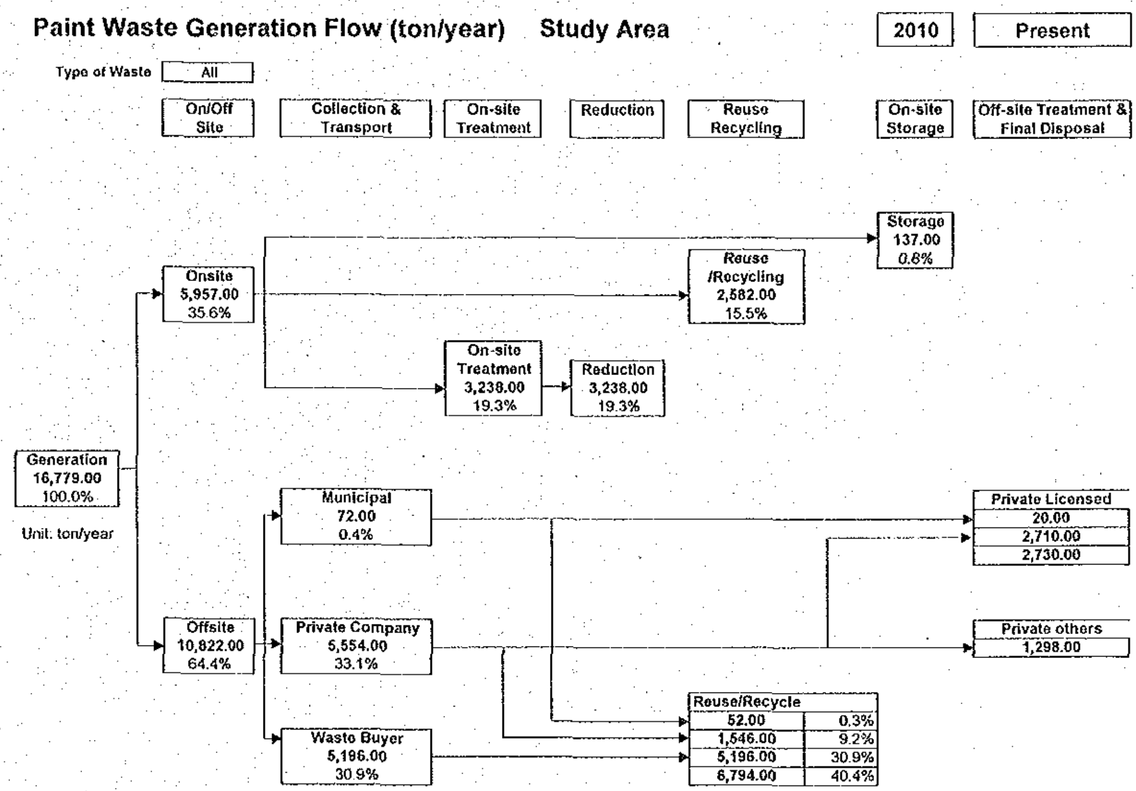

Figure 4-1: Flow of Waste from the Paint Factories in the Study Area in 2010

d. **Recommendations**

With the understanding as above, the team examined an improvement plan for waste that matters to the factories, namely, sludge, waste paint, wastewater, dust and waste solvent. The team's recommendations can be summarized below.

1. Since the increase in labor cost is anticipated as Thai economy develops, the further promotion of waste reduction is required in order to maintain the present state of low waste generation. In particular, waste listed below that is at present paid for off-site disposal will become more costly for the factories

as cost for labor force and appropriate treatment rises. The team recommends the countermeasures summarized below to the paint factories for further waste reduction.

Table 4-1: Measures to Reduce Waste from Paint Industry

Type of Waste	Measures
Sludge	• To wipe paint off the internal tank wall before washing. • To set aside part of process water, use it to wash tank, and mix it with the product. • To cover the filling tank to prevent paint remained on the wall from drying out and sticking to the wall firmly. • To produce lighter colored paint earlier than darker colored paint in order to make it easy to wash the tank when color is changed.
Waste paint	• To introduce an automatic color matching system to prevent over production due to errors in matching colors. • To minimize the content of drying agent that accelerate the formation of gelled paint by examining whether its content is appropriate. • To make a production plan in which reactive resin is used up as much as possible to prevent it from being left in storage. This is because if reactive resin is used as material after stored for a long time, paint turns to gel faster than normal.
Wastewater	• To wipe paint off the internal tank wall before washing. • To set aside part of process water, use it to wash tank, and mix it with the product. • To cover the filling tank to prevent paint remained on the wall from drying out and sticking to the wall firmly. • To produce lighter colored paint earlier than darker colored paint in order to make it easy to wash the tank when color is changed. • To examine the introduction of on-site wastewater treatment facility in case where wastewater is treated off-site. • To separate waste for cleaning into three, i.e. water for the primary cleaning, water for the second cleaning and water for the final cleaning, and use it for each purpose repeatedly.
Dust	• To use toner pigment, i.e. pigment mixed with resin, to prevent pigment, which is powdery, from dispersing into the air when being put into the mixing tank.
Waste solvent	• To wipe paint off the internal tank wall before washing. • To set aside part of solvent to be used as an ingredient, use it to wash tank, and mix it with the product. • To cover the filling tank to prevent paint remained on the wall from drying out and sticking to the wall firmly. • To produce lighter colored paint earlier than darker colored paint in order to reduce solvent needed for tank cleaning. • To set aside part of resin to be used as an ingredient, use it to rinse waste paint in a pigment disperse system, and mix it with the product.

2. In order to keep the present high reuse/recycling rate in spite of the future changes of social and economic conditions, the team recommends the following countermeasures.

- To reuse waste at cement factories as alternative fuel.